LITHIC RAW MATERIAL USE PATTERNS IN MINNESOTA

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By

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ABSTRACT

This thesis examines lithic raw material economies, specifically raw material availability and use, in Minnesota and adjacent parts of Iowa, Manitoba, North Dakota, Ontario, South Dakota and Wisconsin. It addresses the period of traditional stone tool making in the region, beginning around 13,000 ka and continuing to the demise of stone tool technology within the last two centuries. Results are presented in the form of two models.

The first model addresses the challenges of understanding raw material availability in a landscape dominated by glacial sediment and also including primary geologic sources. The model proposes a set of resource regions and subregions, each with a different complement of raw materials. The regions are based on the geologic history of the region, supplemented by information from raw material surveys and refined in light of archaeological toolstone distributions.

The second model addresses the challenges of understanding variations in raw material composition between archaeological assemblages. The model is based on an analytical approach termed "utility analysis," which evaluates the potential utility of various raw materials in a matrix defined by relative flaking quality (X axis) and package size (Y axis). The addition of a Z axis (intensity of use) creates a conceptual space for the comparative examination of lithic raw material data from different assemblages, regardless of specific raw material composition.

This utility analysis is applied to lithic data from about 1,200 archaeological sites. Based on the results, the model proposes four raw material use patterns that can account for much of the variation in the raw material composition of assemblages. Each pattern is geographically and chronologically expansive, but also chronologically delimitable. This raises the possibility of using raw material composition as a diagnostic characteristic to help determine general chronology or cultural affiliation, especially in the absence of other diagnostic indicators.

LITHIC RAW MATERIAL USE PATTERNS IN MINNESOTA

CHAPTER 1. INTRODUCTION AND BACKGROUND . . . .

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CHAPTER 1. INTRODUCTION AND BACKGROUND

INTRODUCTION

For thousands of years, stone-tool makers in what is now Minnesota had a choice of dozens of flakeable raw materials. The choice was not trivial. Stone tools were a basic part of day-to-day life and essential to survival.

The choices that these flintknappers made changed to keep up with new environmental conditions, hunting or farming strategies, cultural preferences and other factors. And the choices that these flintknappers made are reflected in the record that they left – in the lithic artifacts that are more abundant than any other kind of artifact in this region.

If we were to accept that these artisans simply used any piece of flakeable stone that came into their hands, without regard to its size or composition or durability (cf. Brantingham 2003), then we could expect that lithic assemblages would simply reflect the resource base and would look the same in every case. But if we were to expect that these artisans were more clever, that they matched the characteristics of raw materials to their tool needs (cf. Crabtree 1967; Dibble 1991; Williams 2010), then we could expect that lithic assemblages would vary with other changes we already see through time. The toolmakers' choices would be reflected in changes in the raw material composition of lithic assemblages.

I maintain that this is in fact the case. The raw material composition of lithic assemblages changes from time to time and place to place, and it changes in a systematic way that we can identify and study. In fact, we can turn raw material composition into a diagnostic tool that allows us to take a fresh look at chronology, cultural affiliation, site structure and other factors.

To begin uncovering this kind of raw material patterning, we first have to answer two questions: What choices did ancient flintknappers face? What choices did they make? This thesis will explore those two questions. As these are sorted out, it should be possible to push farther and look deeper and explore underlying questions about how and why changes occurred. But those are largely questions for the future.

For now, I will focus on choices faced and choices made, and attempt to answer each with a model. The first model – addressing what choices were faced – will attempt to explain in some detail what raw materials were available and where they could be found. The second model – addressing what choices were made – will examine long-term trends in raw material use, describe a set of raw material use patterns, and explore the application of raw material analysis to regional sites.

Development of Regional Lithic Raw Material Studies

Over several decades, archaeologists in the Upper Midwest have amassed enormous collections of lithic artifacts and sets of data about those artifacts. We have used various analytical approaches to extract information from these collections, examining factors like typology (e.g., Jenks 1937; Kehoe 1966, 1974; Goltz 2001), technology (e.g., Neumann and Johnson 1979; Myster 1996; Mulholland and Menuey 2000), use wear (e.g., Neumann 1988; Sather 1989), and raw material (e.g., Romano 1991a-d, 1994a-c; Gonsior 1992a-d).

In the realm of raw material studies, we have pulled together an increasingly comprehensive and detailed picture of lithic raw material resources in the region (e.g., Nelson 1992, 2003; Boszhardt 1994, 1998a; Low 1995, 1996; Lindenberg 1996; Lindenberg and Rapp 2000; Klawiter 2001; Saini-Eidukat and Michlovic 2003). Knowledge of the resource base has in turn supported examination of how raw materials were used, often concerning the movement of raw materials and sometimes concerning the selection of raw materials (e.g., Ahler 1977; Arthurs 1982, 1986; Clark 1984; Gonsior and Yourd 1990; Hohman-Caine and Goltz 1995b; Hamilton 1996; Bakken 1998).

For example, Knife River Flint (KRF) was one of the earliest materials to be described in the region. In the period 1908 to 1918, Wilson described Hidatsa use of the KRF quarries (Weitzner 1979:240), and a few years later Crawford (1936) further described the quarries. In 1954, Lehmer examined the reliance of Middle Missouri Tradition populations on KRF and contrasted it with Coalescent Tradition reliance on other resources. In 1970, Clayton et al. provided petrographic descriptions of KRF, information to help distinguish it from potentially similar materials, and more information on the KRF quarries. This helped with identification of KRF in far-flung collections, so that in 1984 Clark could examine the midcontinental exchange of Knife River Flint in the Middle Woodland period.

Around the same time, Ahler (1977:132) continued Lehmer's line of research, based on the

> premise... that studies of lithic resource exploitation must be grounded in a firm understanding of the geologic and geographic parameters of the natural resource base. Toward this end, field reconnaissance and geologic information are used to define 12 stone types which occur in high frequency in the chipped stone artifact assemblages and which have reasonably well defined natural source locations and conditions.

Ahler then goes on to discuss the distributions and characteristics of 12 raw materials found on sites in north-central South Dakota, and examine their occurrence at four sites near Mobridge, South Dakota. He notes that it "is suspected that there is a non-random relationship between variation in tool manufacturing technology and variation in the flaking qualities and available size of a given raw material" (Ahler 1977:140). He also attempts to control for technological variations by looking at

> four major tool technological classes... (1) small thin bifacial tools made almost exclusively by pressure flaking... (2) large thin bifacial tools requiring controlled percussion thinning with or without pressure flaking... (3) patterned unifacial tools and hafted slotting or graving tools; and (4) cores and core tools, which include heavy percussion flaked chopping, butchering and scraping tools made on cobbles or boulders, and bipolar and non-bipolar cores. [Ahler 1977:141]

In addition to examining the site data in terms of the 12 raw materials and 4 technological classes, he also found it "instructive to collapse several of the raw material classes into a smaller number of major groups, each of which has a general source direction in relationship to the location of the archaeological sites.... [F]ive main resource areas are defined: South, Southwest, West, Northwest, and Local" (Ahler 1977:141).

He concludes that there are clear and consistent differences in raw material use patterns between the two cultural groups he is considering. These include a dependence by the Coalescent Tradition on raw materials occurring to the south, and by the Middle Missouri Tradition on Knife River Flint found to the north. In addition, both traditions showed strong reliance on locally available raw materials.

This and similar work over the next few years progressed through definition of a fuller range of raw materials, better information on their distributions, and an increasingly regional rather than local perspective (e.g., Morrow 1984a; Bakken 1985; Low 1995, 1996). For the study of raw materials in Minnesota, an important point was reached around 1990 with the collaboration of a group of researchers with different regional expertise (e.g., Romano 1991a-d; Gonsior 1992a-d; Bakken 1993). The resulting synthesis of information (Bakken 1995a, 1997) has supported more consistent identification and analysis of raw materials.

Also in 1990, Gonsior and Yourd looked at coefficients of similarity for several lithic assemblages from Chippewa and Renville counties in order to examine raw material use. While the statistical examination did show clustering of assemblages, they noted that "the significance of the seriation is difficult to assess" (Gonsior and Yourd 1990:93), chiefly because of the lack of a broader context to support interpretation of the results. They concluded by noting that

> If certain variations in the relative proportions of lithic raw material types could be shown to be indicative of cultural affiliation, comparison in this manner could be of considerable importance. Such an assumption would be premature at this date, however. It is conceivable, for example, that the same group of people could leave decidedly different patterns of raw material use depending upon the local or even long-distance availability of raw materials or what function the stone is to perform. But it is also conceivable that general preferences for lithic raw materials may have varied from group to group through time. [Gonsior and Yourd 1990:94]

Since that point, discussions of raw material use patterns have grown more frequent, detailed and confident. To cite a few examples, in 1995 Hohman-Caine and Goltz (1995b) produced lithic raw material profiles for a number of sites in north-central Minnesota and pointed out differences between Paleoindian, Archaic and Woodland assemblages. In 1996, Gonsior et al. used a regional perspective to look at changing patterns of raw material use in three stratified components at the Mazomani/Kvistero site in southwestern Minnesota. A 1998 synthesis of a large body of research around Mille Lacs Lake included an examination of raw material use that also proposed distinctive patterns for Paleoindian, Archaic and Woodland sites (Bakken 1998). In 2001, Mulholland and Woodward included discussion of raw material use patterns in evaluating the chronology and cultural associations of the Pauline Lake site in northeastern Minnesota. In 2005, Gonsior and Radford discussed distinctive features of raw material use at late prehistoric sites in an area of northwestern Minnesota.

Nature of the Present Problem

The results of such analyses, while valuable, have necessarily focused on particular sites, time periods, regions or raw materials. The present challenge is to build on this previous work and provide an expanded general context for regional raw material studies, and thus to expand research opportunities. To do this will require looking at all of Minnesota and nearby parts of neighboring states and provinces (Figures 1-1, 1-2; Table 1-1), beginning with the earliest evidence for a human presence in the state and concluding with the demise of traditional flintknapping technology. This expanded scope will not only support statements about raw material use for particular times and places, but also facilitate broader comparisons and support examination of longterm trends.

Figure 1-1. Research region, showing states and provinces discussed.

Figure 1-2. Minnesota and counties (see Table 1-1 for key to abbreviations).

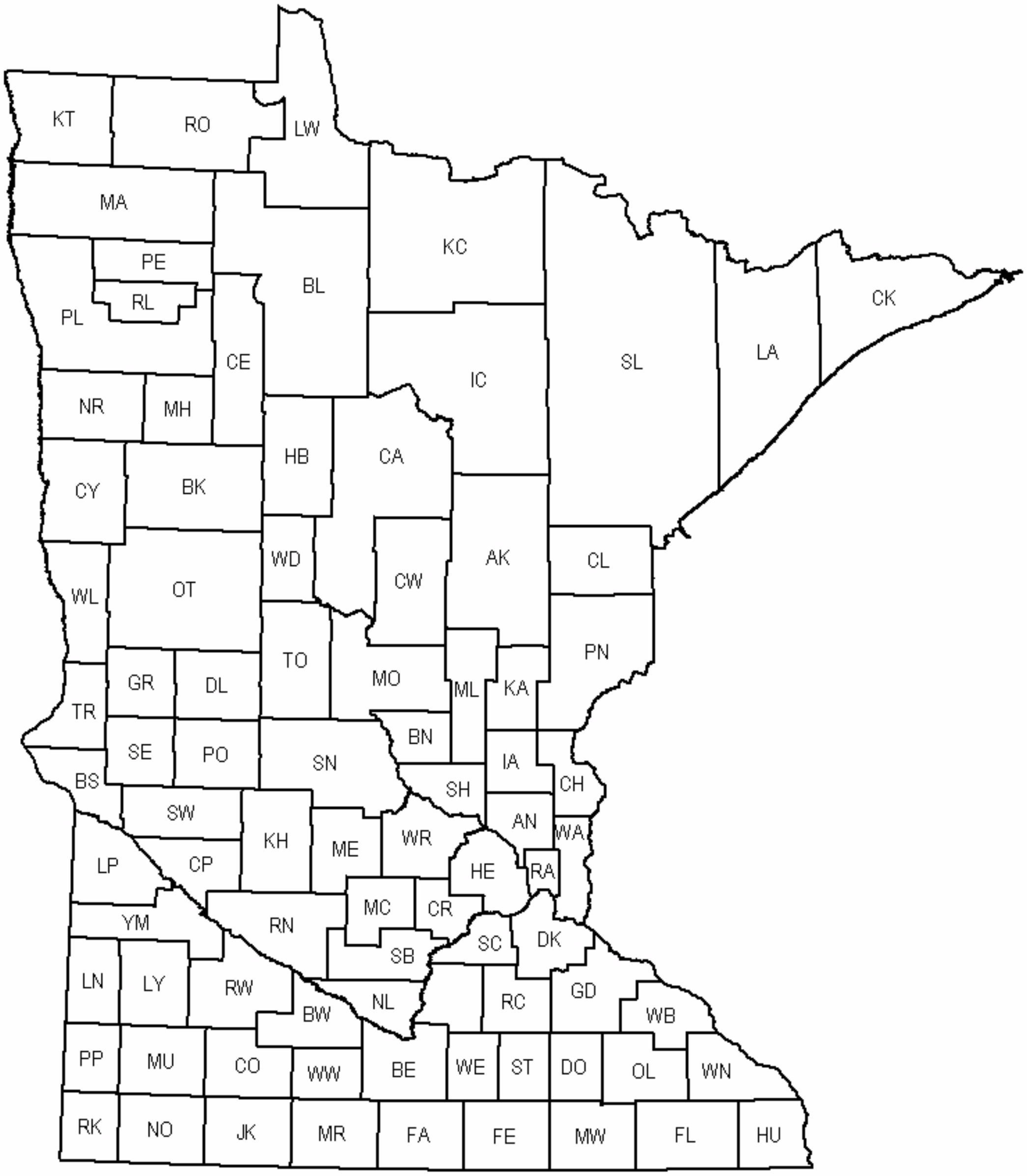


Table 1-1. County abbreviations used in Smithsonian trinomial site designations for Minnesota and selected counties in neighboring states.

Abb.	County	Abb.	County	Abb.	County
AK	Aitkin	IA	Isanti	PN	Pine
AN	Anoka	IC	Itasca	PO	Pope
BE	Blue Earth	JK	Jackson	PP	Pipestone
BK	Becker	KA	Kanabec	RA	Ramsey
BL	Beltrami	KC	Koochiching	RC	Rice
BN	Benton	KH	Kandiyohi	RK	Rock
BS	Big Stone	KT	Kittson	RL	Red Lake
BW	Brown	LA	Lake	RN	Renville
CA	Cass	LE	LeSueur	RO	Roseau
CE	Clearwater	LN	Lincoln	RW	Redwood
CH	Chisago	LP	Lac Qui Parle	SB	Sibley
CK	Cook	LW	Lake of the Woods	SC	Scott
CL	Carlton	LY	Lyon	SE	Stevens
CO	Cottonwood	MA	Marshall	SH	Sherburne
CP	Chippewa	MC	McLeod	SL	St. Louis
CR	Carver	ME	Meeker	SN	Stearns
CW	Crow Wing	MH	Mahnomen	ST	Steele
CY	Clay	ML	Mille Lacs	SW	Swift
DK	Dakota	MO	Morrison	TO	Todd
DL	Douglas	MR	Martin	TR	Traverse
DO	Dodge	MU	Murray	WA	Washington
FA	Faribault	MW	Mower	WB	Wabasha
FE	Freeborn	NL	Nicollet	WD	Wadena
FL	Fillmore	NO	Nobles	WE	Waseca
GD	Goodhue	NR	Norman	WL	Wilkin
GR	Grant	OL	Olmsted	WN	Winona
HB	Hubbard	OT	Otter Tail	WR	Wright
HE	Hennepin	PE	Pennington	WW	Watonwan
HU	Houston	PL	Polk	YM	Yellow Medicine

Such an undertaking is not without its challenges. One of the first is the glaciated landscape. Archaeologists have often shied away from studying glacial raw materials resources (perhaps with good reason) and preferred to concentrate on primary raw material sources (but see Shelly 1993). For example, in his essential reference works on lithic raw materials in Iowa, Morrow (1984a, 1994) notes that glacial sediments are essentially the only source of raw materials in the northwest quarter of the state, but his papers concentrate almost exclusively on raw materials from primary geologic sources. We see a similar situation in an innovative on-line guide to raw materials in east-central Illinois (Stelle and Duggan 2003). The guide provides thorough information on primary-source materials, but introduces glacially-derived material in this fashion:

> A final point of confusion for those of us working in east-central Illinois is that much of the chert being exploited was recovered from glacial deposits. Glacial deposits contain EVERYTHING [emphasis in original]. Consequently, Glacial Till Chert represents our "Other" or catch-all category. One should probably begin an analysis by reviewing the properties of Glacial Till Chert.

In a different kind of example, Church (1988:30) characterized a relatively modest survey of raw materials in Minnesota glacial sediments (Bakken 1985) as "pioneering."

This kind of reticence probably arises from the relative complexity of secondary sources compared to primary sources. Glaciers could transport a material from its area of origin to multiple destinations, and materials from multiple areas of origin to a single destination. Materials might also have multiple vectors of transport; this is, they were moved multiple times in different directions (e.g., Prest 1990). Advancing ice could mix old and new tills, further complicating the picture of material distributions (e.g., Chernicoff 1983; Goldstein 1985). In contrast, primary sources normally provide a single raw material in a restricted territory with a predictable distribution (e.g., Goings 2003). The latter situation better lends itself to the kinds of source characterizations and provenance studies that archaeologists are accustomed to conducting (e.g., Hoard et al. 1993; Klawiter 2001).

Somewhat ironically, the very characteristics that make secondary-source studies challenging may also make them illuminating. Consider that a primary material source typically has one available raw material, and thus one choice – take it or leave it. In this situation, we can study the choice of materials between sources, but not within sources. Proximity to source thus tends to be an important factor in raw material selection. At a secondary material source, however, there is likely to be a mix of raw materials, each with distinctive characteristics. A flintknapper might choose one or some or all of the immediately available raw materials. Proximity is less of a factor in raw material selection. This provides an avenue for gaining potentially valuable insights into raw material selection and use patterns.

The scale of both patterns and of observation creates a second challenge in attempting to construct an overall context for raw material studies. The patterns are likely to cover hundreds to thousands of square miles and hundreds to thousands of years, and observation must correspond to this scale. In a sense, the difference between the previous and current work is the difference between a keyhole view and the big picture, or between local details and overall structure. The local view can be framed in terms of particular raw materials, while the big picture must transcend particular materials and be framed in more abstract terms like area of origin, workability, or predominant use.

The scale of observation also requires a large data set, in terms of geographic and temporal coverage, number of individual specimens, and number of sites or assemblages. Although it is difficult to estimate the size of an adequate sample, we can examine a few numbers to gain some order-of-magnitude estimate. Initially it would help to have data from most or all of the state's 87 counties to support examination of overall geographic patterning. Since one site is not adequate to represent overall raw material use in a county, a good sample would include multiple sites per county. If we expected to have, for the sake of discussion, an average of 10 sites per county and 250 artifacts per site, the sample would require 870 sites and 174,000 artifacts. Using a different approach, suppose that the state has seven distinguishable resource regions or subregions and four identified raw material use patterns. This results in 28 unique combinations, each of which should be represented by multiple sites. Using the same figures of 10 sites and 250 artifacts, the sample would require 280 sites and 70,000 artifacts. However, some sites will be atypical of recognized use patterns, some contain mixed components that represent no single use pattern, and others provide samples too small to be useful in characterizing use patterns. This effectively increases the size of the required sample. If a third of the sites fit into one of these categories, the required sample size would increase to about 420 sites and 105,000 artifacts. Including sites from nearby areas outside the state further edges up the size of the sample.

Although these figures only provide an order-of-magnitude estimate, they suggest that an adequate sample will include several hundred sites and close to 200,000 artifacts. Such a sample is clearly available, since there are several thousand recorded prehistoric sites in the state and curated collections from a majority of these. The numbers also show, however, that the sample cannot be procured only by first-hand examination of collections. The time required would be prohibitive. Instead the data must be gathered from a variety of available sources, including data furnished by colleagues, extracted from the grey-report or regularly-published literature, or produced by first-hand examination of collections.

A third challenge in attempting to construct an overall context for raw material studies involves determining which elements of an assemblage's raw material composition are potentially useful in analysis or diagnosis. Previous research of the sort cited above has generally examined individual raw materials as a percentage of the total lithic assemblage. While this has proven useful, further progress will involve using broader and more abstract categories that group or compare raw materials in different ways. As suggested, the local view can be framed in terms of particular raw materials while the big picture must transcend particular materials and be framed in more abstract terms like area of origin, workability, or predominant use. A good portion of the current research involves identifying such analytical methods.

Approach to the Problem

The first step in examining raw material use patterns is to take a closer look at the natural distribution of toolstone across the landscape, since it is difficult to determine what elements of raw material patterning are cultural until it is apparent what elements of raw material patterning are natural. This involves revising and refining an earlier model of raw material availability (Bakken 1997).

The previous model proposed that Minnesota had three raw material resource regions, each with a list of associated raw materials ranked by primary, secondary and minor importance. Definition of the regions was based primarily on the gross bedrock and Quaternary geology of the state (e.g., Hobbs and Goebel 1982; Morey 1993; Wright 1972), and the association of raw materials with regions was based partly on raw materials samples from around the state and partly on the occurrence of raw materials in archaeological sites. The revised model (Chapter 3. Lithic Raw Material Resource Base and Regions) is also founded on bedrock and Quaternary geology, and the revision incorporates some geologic information that was not previously considered (e.g., Goldstein 1985; Lineburg 1993; Patterson 1993). The archaeological distribution of raw materials is again considered but this time in connection with defining regional boundaries, a matter that is discussed later in greater detail (Chapter 3).

In support of this revision, there is also fresh discussion of raw material nomenclature (Chapter 2. Methods and Terminology). This is a further articulation of a hierarchical system that proceeds through a number of steps from generic categories to named subvarieties. The discussion includes proposals to adjust the names of some materials, and to define raw materials "groups." A group would include raw materials that are closely related in origin or distribution. The Border Lakes Greenstone Group, for example, includes related raw materials that originate in the greenstone belts of northern Minnesota and northwestern Ontario and that share substantially similar glacial distributions. Hopefully this step helps to reconcile discordant naming systems that remain in use for some materials, to enable discussion about raw materials in a way that focuses more on origin and distribution and less on individual raw materials, and to encourage more accurate description of raw materials.

The next step in the examination also involves looking for ways to classify, cluster and compare raw materials in ways that will better elucidate use patterns (Chapter 4. Lithic Raw Material Use in Minnesota and Region). Looking at raw materials by region of origin has already proven useful (e.g., Gonsior et al. 1996), and this approach should be developed further. Other possible approaches include size and flaking quality of the raw material stock (cf. Andrefsky 1994a, 1994b), predominant use in terms of tool production (e.g., Gonsior and Radford 2005:44; cf. Parry and Kelly 1987), or sample diversity (cf. Kintigh 1989; Rindos 1989).

The final step is to construct a kind of historical framework (Chapter 5. Discussion and Conclusions). In part this is a chronological model with a series of sequential patterns, and in part it is a framework with contemporaneous patterns. These form a sort of foundation for a history of raw material use and a discussion of general long-term trends. This includes not only the use of local toolstone, but also fluctuations in the circulation of nonlocal raw materials including the common exotic toolstones.

Certain kinds of assemblages prove especially valuable in constructing such a model. These include single-component assemblages with absolute radiometric dates or with clear typological associations that allow connection to established chronologies. Sites with stratified deposits are also helpful in examining trends through time. Identical geographic location for each component implies uniform access (or at least proximity) to any given raw material source, which makes it more likely that differences between strata can be attributed to cultural, economic, technological or similar factors.

In order for this work to be useful, of course, it needs to contain elements beyond the models themselves. This introductory section provides background information on regional geology, archaeology, and the development of regional raw materials studies. A concluding section (Chapter 5. Discussion and Conclusions) evaluates strengths and weaknesses of the models, as well as suggests directions for further research. In addition an effort has been made to craft the final document in a way that will make it useable as a research tool, in effect a "handbook" for regional raw material research.

BACKGROUND

Since this work draws on information from two disciplines, it seems advisable to include selected background for both regional geology and archaeology. More specifically the first includes a very basic overview of regional geology, including relevant aspects of both bedrock and glacial geology. This overview focuses on Minnesota, but necessarily covers a broader area for parts of the discussion. The archaeological background focuses on the culture-history framework, which covers the general periods used in the discussion and their approximate chronology. This is included in part for the benefit of readers who are not regional archaeologists, and in part because archaeologist in the region have been known to use somewhat different culture-history frameworks. This overview is only intended to support the attendant discussion, not to take a definitive position on regional culture-history and chronology. In addition, there is a brief overview of the parameters and character of the data used for this study.

Overview of Regional Geology

In order to understand the lithic raw material resources of Minnesota, it is necessary to have some understanding of the geology of Minnesota. The geologic history of Minnesota is long, complex, and intensively studied. Since this thesis is about geoarchaeology rather than geology, however, it seems advisable to present a general overview and to abstract key features of the state's geological history. The "Geology of Minnesota" entry in Wikipedia (2008) provides an especially good starting point:

> The state's geologic history can be divided into three periods. The first period was a lengthy period of geologic instability from the origin of the planet until roughly 1,100 million years ago. During this time, the state's Precambrian bedrock was formed by volcanism and the deposition of sedimentary rock and then modified by processes such as faulting, folding and erosion. In the second period, many layers of sedimentary rock were formed by deposition and lithification of successive layers of sediment from runoff and

> repeated incursions of the sea. In the third and most recent period starting about 1.8 million years ago, glaciation eroded previous rock formations and deposited deep layers of glacial till over most of the state, and created the beds and valleys of modern lakes and rivers.

Each of these periods has made significant contributions to the raw material resource base. The first period is most influential in the materials of the West Superior Resource Region, the second period in the Hollandale Region, and the third period in the South Agassiz and Pipestone regions (see Chapter 3).

We can also take a similar arms-length view of the structural geology of the state, based on overviews presented by Bray (1977) and Ojakangas and Matsch (1982). In simplest terms, the Transcontinental Arch forms a backbone of ancient rock stretching northeast to southwest through the state. These rocks range in age from about 1 to 3 billion years, and many are part of the original nucleus of the North American continent. In general, the oldest rocks are located to the northeast; the rocks to the southwest, while still ancient, are younger. In the southwest these are mostly sedimentary rocks, with igneous rocks becoming increasingly common to the northeast. Metamorphic alteration also becomes more intensive and complex to the northeast. Typical constituent rocks in the southwest include Sioux Quartzite and Catlinite. Important constituent rocks in the northeast include granites, basalts, iron formation, quartzites and greywackes.

On either side of the Transcontinental Arch are two basins that were repeatedly transgressed by the sea and filled with deep sedimentary strata. These are the Williston basin to the northwest and the Forest City basin to the southeast. More specifically, the part of the Forest City basin that occupied parts of Minnesota and Wisconsin is known as the Hollandale Embayment. It is this feature that lends its name to the Hollandale Resource Region (see Chapter 3), and it is the sediments of this basin that gave rise to many regional toolstones. The sediments in these basins include Paleozoic carbonates, shale and sandstone. Many of these sedimentary rocks are Devonian and Ordovician, ranging in age from roughly 350 to 500 million years.

In much of the state, this bedrock is blanketed by glacial till that can be as much as several hundred feet thick. Exceptions include southeastern Minnesota, which is generally beyond the limits of easily-discerned glacial sediment; parts of northeastern Minnesota, where bedrock is intermittently exposed in topographic high points or where glacial sediments are thin; and scattered locations such as high quartzite ridges or deeply-eroded valleys.

There is little information on early glaciations; conceivably they could have included broad continental ice sheets. The accessible information comes mostly from later ice advances in the form of lobes that flowed beyond the margins of the continental ice sheet. The lobes arrived from various directions, carrying sediments that originated in different areas and are therefore different in character. Frequently an ice lobe would also pick up sediment deposited by previous lobes, mixing sediments of different origins and spreading older sediments to new areas. One result is that an individual piece of toolstone might have been transported multiple times in different directions. Another result is a fairly complex glacial landscape.

In simplest terms, we can think in terms of older tills and younger tills. The older tills are not as well understood, either geologically or in terms of raw materials, since they are mostly covered by younger tills. Exposures of older tills in the study region are mostly limited to 1) an area in extreme southwestern Minnesota, small parts of eastern South Dakota, and into northwestern Iowa; 2) a band beyond the limits of younger tills in part of southeastern Minnesota and into northeastern Iowa; and 3) scattered exposures in deeply eroded river valleys such as the Minnesota River Valley. The younger tills are much better understood since they are extensively exposed. For our purposes, we can think in terms of repeated, interacting ice advances from three sources. One set of advances came from carbonate-rich terrain to the northwest (e.g., the Des Moines lobe), a second from the Canadian shield to the north and northeast (the Rainy lobe), and a third from the northeast and the vicinity of Lake Superior (the Superior lobe). Each of these left distinctive sediments and different sets of raw materials.

This geological overview considers rocks and sediments from the surface to great depths. Toolstone, however, was gathered at or near the surface. Therefore we also need to consider the degree to which these geological periods and structural features are expressed at the surface in different parts of the state. In general, the best surface expressions of the first period and Transcontinental Arch are found from northwestern Ontario, into the northeast part of Minnesota, and including parts of northern Wisconsin. To the southwest, glacial sediments come to dominate the landscape and bedrock exposures become increasingly scarce. The best surface expressions of the second period and the marine-basin deposits are found in southeastern Minnesota, into west-central and southern Wisconsin, and including large parts of eastern and southern Iowa. The sedimentary rocks of the Williston basin to the northwest are not generally exposed in the study area, except for some exposures in Manitoba. The third, glacial period dominates the rest of the landscape, including most of

Minnesota, as well as much of the eastern Dakotas, northern and western Wisconsin, and northern Iowa. Even in areas where more recent glacial sediments do not dominate the landscape, eroded traces of earlier glaciation can often be found.

Table 1-2. Main divisions in the general culture-history of the Upper Midwest, with approximate chronology.

Division	App. Start	App. End	Notes
Initial Settlement	**?**	**?**	Not well known, and not represented in this study.
Paleoindian *Early* *Late*	**12,500 BP** *12,500* *10,500*	**8,000 BP** *10,500* *8,000*	
Archaic *Early* *Middle* *Late*	**8,000 BP**	**3,000 BP**	There is considerable variation between researchers on divisions and dates within the Archaic.
Woodland *Early* *Middle* *Late*	**3,000 BP** *3,000* *2,100* *1,500*	**100 BP** *2,100* *1,500* *100*	These divisions vary somewhat by region, and are the subject of some controversy.
Village Cultures	**1,100 BP**	**250 BP**	Figures for southeastern Minnesota; village cultures persist later on the Northeastern Plains.
Contact	**AD 1650**	**AD 1830**	
Post-Contact (Historic)	**AD 1830**	**Present**	

Overview of Regional Culture-History

Since this thesis also covers the entire period of human presence in Minnesota, it may be helpful to briefly outline the major culture-historical periods and their general chronology (Table 1-2). The chronology is approximate, a point emphasized by expressing most dates in 500 year increments (cf. Dobbs 1990).

There is currently no generally-recognized evidence for "Pre-Clovis" populations in Minnesota, perhaps because much of the state was covered by glacial ice during this period. Archaeological evidence begins with the Paleoindian period, commonly divided into Early and Late Paleoindian. Early Paleoindian finds are rare, and mostly limited to the southern parts of the state. Late Paleoindian sites are more common, and are found throughout the state. Distinctive characteristics include fluted points (Clovis, Folsom) in the Early Paleoindian, other large lanceolate bifaces in the Late Paleoindian, flaked stone adzes, and prismatic blades.

This is followed by the Archaic period. Some researchers divide this into the Early, Middle and Late Archaic, although these divisions are difficult to define in the region. Other researchers have instead proposed Shield, Prairie, Lake-Forest, and Riverine Archaic traditions, emphasizing geographic rather than chronological differences. Archaic sites are relatively more common, although later Archaic sites seem to be more common than earlier Archaic sites and it can be difficult to specifically identify sites as Archaic. Distinctive characteristics include groundstone tools and the appearance of notching on projectile points.

The subsequent Woodland period is often divided into the Early, Middle and Late Woodland, although many researchers argue that the Early Woodland is incompletely expressed here and prefer the use of Initial and Terminal Woodland. Woodland sites are relatively common, and are found throughout the state. Distinctive characteristics include pottery, burial mounds, and both small notched and small triangular points.

In much of Minnesota, Woodland cultures continue up to the time of intensive Euroamerican settlement. In some areas, however, they are supplanted by what might be called "Village" cultures. In parts of southwestern to south-central Minnesota, these villagers were associated with the Plains Village traditions found to the south and west. In southeastern Minnesota, the villagers were associated with the Oneota tradition and with Mississippian traditions found to the south and east. Distinctive characteristics include semi-sedentary village settlement and horticulture that included maize and other domesticates.

The Contact and Postcontact periods also deserve mention. The Contact period begins with the arrival of the earliest European explorers, and signifies the contact between Old and New World cultures. This period overlaps the ends of the Woodland and Village cultures, and traditional flintknapping continues strong through this time. Distinctive characteristics include the occasional presence of European trade goods. The Postcontact period begins with intensified Euroamerican settlement and the establishment of agricultural and industrial economies. Traditional flintknapping disappears quickly in the Postcontact period.

Overview of the Data Set

Because this research looks at broad trends, it is based on the largest possible data set – any available lithic data from archaeological sites in or near Minnesota. Data from sites near but not in the state were included because state and provincial boundaries are not usually relevant for the precontact period, and any patterns in the data should transgress present geopolitical boundaries.

The basic data set for this study is quite simple. It consists of the total counts of flaked stone artifacts for an assemblage, by raw material. A typical data set, for example, might look like this: Swan River Chert (n=70), Knife River Flint (n=20), Red River Chert (n=5), quartz (n=5).

The utility of the total data set comes not from its complexity, but from its extent. The full data set includes 616,256 artifacts from 1,344 sites (Table 1-3). Note, however, that half of the sample comes from three lithic procurement sites with very large but also very redundant samples: Bradbury Brook (Malik and Bakken 1999, n=126,852), Bass (Stoltman et al. 1984, n=75,324), and Cross (Fleming 2002, n=102,793). Most of the information for the study thus comes from a sample of something over 300,000 artifacts. Preliminary work suggests that this data set is probably not much above the minimum size needed to support the proposed analysis.

The assembled data are furnished by colleagues, extracted from the grey-report or regularly-published literature, or produced by first-hand examination of collections. These data were produced by many parties over a period of about 40 years, so the characteristics and relative quality (in terms of present research goals) vary somewhat. Methods have been devised to assess the relative quality of the data, and to extract useful information from lower-quality data while still segregating it from the general data set (Chapter 2). The assessment of data quality involves looking at factors like the specificity of identification, accuracy of identification, and sampling bias. The percentage of raw materials that are generically identified proves to be an especially useful index of assessing quality.

Sample size is also a consideration, since samples size per site (or assemblage) ranges from 1 to 126,852. The main concern is to understand what size sample is adequate to characterize a lithic assemblage. The question is examined from the perspectives of a simple statistical model and of the behavior of the data (see Chapter 2). The results do not provide definitive answers, but do suggest a set of working guidelines. First, profiles based on a sample of fewer than 100 lithic artifacts should be used with caution. Second, profiles based on a sample of about 150 artifacts probably present a good picture of raw material use, although rare materials may be missed. Third, profiles based on a sample of about 300 or more pieces should provide a dependable profile and also a good chance of detecting rare materials. Fourth, a site with a relatively homogenous population of lithic artifacts can be adequately profiled by a smaller sample.

Table 1-3. Data set general overview by geographic area, data quality.

Place	**No. of Assemb.**	**No. of Artifacts, All Sites**	**No. of Artifacts, Better-Data Sites**
Iowa	**5**	**18,992**	**5,645**
Manitoba	**1**	**167**	**167**
Minnesota	**1,228**	**256,893**	**207,864**
South Agassiz	*508*	*59,291*	*46,986*
West Superior	*329*	*143,198*	*111,308*
Hollandale	*228*	*42,187*	*37,712*
Pipestone	*36*	*303*	*303*
Multiregion Counties	*127*	*11,914*	*11,555*
North Dakota	**83**	**37,560**	**37,560**
South Dakota	**2**	**59**	**59**
Ontario	**87**	**18,759**	**18,759**
Wisconsin	**4**	**6,310**	**6,310**
Sites segregated from general tallies because of very large, redundant samples			
21ML42, Bradbury Brook	1	126,852	126,852
47GT25, Bass	1	75,324	75,324
21WA93, Cross	1	102,793	102,793
TOTAL	**1,413**	**643,709**	**581,333**

CHAPTER 2. METHODS AND TERMINOLOGY

I like to say that if you're looking for certainty, go
into mathematics. Don't go into ancient history.
— Hershel Shanks

In the years since the pioneering work of Bordes, Crabtree, Semenov and others reintroduced lithic technology to the modern world, lithic studies have become an important focus in archaeology, and a number of different specialties have developed. Some researchers focus on reduction methods and strategies, for example. Others concentrate on use wear analysis, based on experimental tool use and the microscopic examination of surficial changes created by tool use. Yet others concentrate on raw materials.

Even within the subspecialty of raw material studies, a number of different emphases have emerged. Much of the foundational work focused on defining and describing the raw material resource base and providing information to aid researchers with raw material identification (e.g., Ahler 1977; Bakken 1985, 1997; Boszhardt 1998a; Carlson and Peacock 1975; Gonsior 1992a-d; Morrow 1984a, 1994; Morrow and Behm 1985; Mulholland and Menuey 2000; Nelson 1992, 2003; Porter 1961, 1962; Romano 1991a-d, 1994a-c). These works commonly described the geology of individual raw materials, raw material appearance at macroscopic and low-power microscopic levels, texture and flaking characteristics, distribution, and sometimes petrography.

Other work has focused on sourcing, or connecting lithic artifacts to particular stone sources using tools like trace element analysis (e.g., Anderson et al. 1986; Boszhardt 1998b; Klawiter 2001; Lindenberg 19996; Lindenberg and Rapp 2000). (Note this kind of sourcing is also used with other archaeological materials like metals and ceramics [e.g., Rapp et al. 1984].) This kind of analysis usually focuses on selected raw materials that come from sources with a limited and well known extent. The results are specific, detailed, quantitative and replicable. The studies tend to be limited in scope, however, both because of cost and because the technique can be destructive to samples.

Sourcing work is also done based on macroscopic and low-power microscopic visual identification of raw materials. Although the resulting identifications are arguably less accurate, this method also produces good results and has the advantage of being low cost, nondestructive, and generally broader in scope. In addition, visual identification can be calibrated by reference to petrographic characterizations or trace element analyses (e.g., Saini-Eidukat and Michlovic 2003).

It is interesting to note that both raw material resource and sourcing studies tend to concentrate on raw materials that come from primary bedrock sources or some kind of lag deposit in close proximity to the material's original source. Such sources are relatively restricted in extent, and can be reasonably well defined by reference to local geology. Less work has focused on the raw material resources of glaciated landscapes, and perhaps less still on "sourcing" studies in such regions. One reason for this disparity may be a perception, right or wrong, that stone from primary or lag deposits was preferred over stone from glacial sediments, at least in areas where both were available. A second reason may be the inherent complexity, the "messiness," of determining raw material distributions and other base-line information in areas where glaciers have spread materials over vast territories and where multiple glaciations have spread materials in multiple directions and mixed materials from multiple sources.

In contrast, the research introduced here concentrates largely on recently glaciated landscape. The research includes both definition and description of the raw material resource base, as well as an exploration of how the raw materials were used. To some extent this puts the current research outside the better-established territory of raw material studies, which also means that established analytical ideas, methods and terms are not always suitable. Although I use established approaches whenever possible, it has been necessary to extend the analysis in order for it to function here. To some degree it has also been necessary to adapt established approaches and forms in order to create a better-integrated analysis. The specific goal of this section is to explain the analytical concepts, methods and terms specifically as they are used here.

Some of the methods and terms used in this study are relatively standard and widely used, and therefore will not be reviewed here. Others are either not standardized, not widely understood, or are more or less unique to this paper. These are discussed in the following pages.

THE NATURE OF THE DATA

Because this research looks at broad trends, it is based on the largest possible data set – any available lithic data from archaeological sites in or near Minnesota. Sources include several hundred artifact catalogs furnished by colleagues at the Archaeology Department, Minnesota

Historical Society; lithic inventories and catalogs furnished by other colleagues; lithic inventories in Cultural Resource Management (CRM) contract reports, most on file at the State Historic Preservation Office (SHPO) or Office of the State Archaeologist (OSA); and lithic data published in various books or journals.

The total data set includes over a 600,000 lithic artifacts from more than 1,300 sites, representing the work of many dozens of researchers (Table 1-2). The samples vary in size from a single artifact to over 100,000 pieces (the latter in the case of two toolstone procurement sites). About ninety percent of the sites are in Minnesota, but data from sites in nearby parts of adjacent states and provinces were also used when they were available. Most of the data were generated since 1990, although some of the data come from as early as the 1960s.

Given such factors, the data tend to vary in nature, quality and utility. It is possible, however, to assess the relative quality and utility of the data sets and also which information is consistent and comparable between different data sets. This kind of evaluation allows the data to be handled in ways that help produce a stronger final analysis.

Selection of Analytical Characteristics

There are many ways to describe and characterize lithic artifacts, depending on factors like the preferences of individual researchers or what analytical questions are being addressed. Common approaches in this region include the method of mass analysis developer by Ahler (1989), the flaking-debris categorizations proposed by Sullivan and Rozen (1985), or the descriptive-flake categories laid out by Montet-White (1968). Some researchers apply these or other systems rather literally, while other researchers use hybrid or individualized approaches. The resulting lithic data sets include elements such as count, weight, size grade, raw material, presence or absence of cortex, and presence or absence of heat treatment – potentially rich information for understanding many aspects of lithic technology. The original intention of this research was to use a number of these characteristics for the broader analysis. Reality, however, intervened.

The variety of analytical approaches ensures that many characteristics are not directly comparable between data sets. In addition, any given characteristic is sometimes present, sometimes absent. Further, for a large number of data sets the logistics of transcribing and organizing such multidimensional data are daunting, and the challenges of deriving analytical methods for multidimensional data sets threatened to founder the basic research goals.

At some point it became apparent that this research would have to focus on the one generally consistent data set – basic raw material counts. This data set was available from a large number of sites, was usually reliable (but see discussion of data quality issues below), and presented sufficient analytical potential and challenges. Thus the basic data set for this study is quite simple. It consists of the total count of flaked stone artifacts for an assemblage, by raw material. A typical data set, for example, might look like this: Swan River Chert = 70, Knife River Flint = 20, Red River Chert = 5, quartz = 5. The utility of the total data set comes not from its complexity, but from its extent.

This is not to dismiss the analytical potential of other kinds of lithic data. In fact, this analysis sometimes delves into the other kinds of information for deeper insights into the dynamics of raw material use patterns. The other data clearly need to be mined, and in other sections of this thesis I provide suggestions on how such research might proceed. Those data do not, however, constitute the focus of this research.

Data Quality

The lithic data used in this study was produced by many parties over a period of about 40 years, so the relative "quality" (in terms of present research goals) varies. Data quality can be difficult to define, but in this case certain specific elements can be considered. They focus on raw material identification, since that is a central factor in this analysis. These elements include specificity of raw material identification, accuracy of raw material identification, as well as limited consideration of sampling factors. Data that is judged to be of weaker quality can still contribute useful information. It is, however, segregated from the better quality (as discussed in the following section) data so that it does not dilute the overall results of the analysis.

Specificity of Raw Material Identification

As discussed below in the section titled "Terminology," a raw material identification can be more specific or less specific. Raw material identification can be thought of as a hierarchy having five levels: unidentified, descriptive generic category, raw material group, specific material, subvariety. As a rule of thumb, more specific identification equates with better data quality. In practice, identification to raw material group often provides good information, identification to specific material usually provides the best information, and identification to subvariety may or may not provide further useful information.

Older reports and catalogs tend to include many generic identifications, which is hardly surprising since many of the current raw materials types had not yet been defined and much less information on raw materials was then available. The data they present is still of some use for the present analysis. Lithic data from the Itasca Bison Kill site published by Shay in 1971, for example, can be partly correlated with current raw material categories to provide useful figures for Swan River Chert, Tongue River Silica, Knife River Flint, and quartz. On the whole, however, Shay's lithic inventory has a large percentage of generic identifications. This indicates relatively low data quality for the entire inventory (in terms of present research goals), so this assemblage was segregated from production of various geographic and chronological totals.

Accuracy of Raw Material Identification

Accuracy is also a consideration in data quality. In some cases, a researcher having limited familiarity with regional materials might systematically misidentify one or more materials. While this does occur it does not seem to be common, probably because of the availability of reference collections and the existence of a substantial set of literature about regional raw materials.

A different kind of situation came to light during the research for this thesis. A published description of Hudson Bay Lowland Chert (HBLC; see Table 2-1 for a list of raw material abbreviations) (Bakken 1997:74) proved to be inadequate, few comparative samples were available, and some of the available samples appeared to actually be other raw materials. As a result, mapping of the lithic data showed an apparent concentration of HBLC in northwestern Minnesota (Appendix 1-8). In fact it appears that while some HBLC is undoubtedly present, the concentration may not exist, and we are left without a clear understanding of the distribution (natural or cultural) of HBLC in the state. There has been similar confusion in the identification of Knife Lake Siltstone, Lake of the Woods Siltstone and Lake of the Woods Rhyolite.

Note that accuracy in identification is better thought of as a property of the assemblage rather than individual artifacts in the assemblage. I have previously argued that although a raw material analysis will not accurately identify every piece in an assemblage, it can still produce an acceptably accurate characterization of the whole assemblage. Some percentage of generic identifications is to be expected, since there is substantial variation in raw material characteristics, small pieces may show a narrow range of identifying characteristics, and some pieces are simply atypical (see Bakken 1997:66). In fact, specific identification of all pieces in a collection is suspect; the researcher may have tried too hard to fit every piece into known categories.

Table 2-1. Raw materials abbreviations used in the text.

Abbrev.	Raw Material	Abbrev.	Raw Material
CVC	Cedar Valley Chert	LSA	Lake Superior Agate
GFS	Gunflint Silica	PdC	Prairie du Chien Chert
GMC	Grand Meadow Chert	RRC	Red River Chert
HBL[C]	Hudson Bay Lowland Chert	SRC	Swan River Chert
KLS	Knife Lake Siltstone	TRS	Tongue River Silica
KRF	Knife River Flint		

Sampling Considerations

In some less common circumstances, site sampling issues can also affect data quality. Some older collections, for example, contain only formal tools or maybe formal tools and flake tools. These artifacts are not representative of the overall raw material representation at a site. In more recent assemblages, quartz flaking debris might not have been collected since it is hard to detect classic flake morphology on quartz. In addition, it seems that many researchers have routinely discarded fractured pieces of basalt, schist, slate and other poor quality materials, not realizing that these pieces could well represent flaking debris from the manufacture of chopping tools. This sort of bias can be harder to detect, and may only be apparent when data can be compared for a large number of sites in a region.

Other data sets include an inventory of only selected parts of a collection. A small set of data used in this thesis, for example, includes only lithic items being removed from collections for repatriation under NAGPRA. These tend to be tools believed to be grave goods. Such data sets are hardly representative of the whole assemblage, and need to be used with caution. Happily such cases are usually easy to identify.

Assessing Relative Data Quality

Conceptually it is helpful to think about specificity of identification, accuracy of identification, and sampling bias in assessing the relative quality of lithic data. In practice, problems with accuracy of identification or sampling bias can be hard to spot systematically (but note the case of HBLC discussed above). Finding them relies more on familiarity with the circumstances surrounding individual collections and reports. Thus the assessment of data quality was made mostly by considering an index of "unidentified material" that addresses specificity of identification.

For each set of data, the counts for various raw materials were grouped into sets of index numbers expressed in percentages. Examples include the percentage of raw materials associated with the different resource regions, exotic raw materials, nonlocal raw materials, and so on. The "unidentified" index includes generically-identified materials like agate, chalcedony, fossiliferous chert, jasper, and burned chert. These materials are grouped as a single item because little is known about their source area or distribution.

At most sites, several percent of the lithic assemblage falls into this category. As a rule of thumb, the present data suggest that as long as this index remains under about 10 percent, data quality is probably fine. Percentages in the low teens may signal a need to take a closer look at the data, but do not necessarily indicate a problem. Figures approaching or exceeding 20 percent indicate that the data quality is probably questionable, and the data should be examined more closely. (Note, however, that there is geographic variation in these numbers.) One indication of a raw material identification problem in such assemblages is the absence of one or more raw materials normally found at sites in the region. For example, a catalog from a western Minnesota site might have 40 percent unidentified raw materials but no Swan River Chert. This suggests a failure to specifically identify Swan River Chert. The catalog and report can then be examined more closely to see if this is the case. If this proves to be the case, the quality of the data set is compromised. Such data sets can then be segregated from the better quality data, as described below.

A high "unidentified material" index does not, however, always indicate problems with data quality. If the usual raw materials have been identified in an assemblage, for example, and in addition there are a large number of generic identifications, it may be that the collection contains many pieces of a nonlocal and unrecognized raw material. In such a case, the overall quality of that data set could be considered good.

Historic Data-Quality Trends

Several hundred digital artifact catalogs were obtained from the Minnesota Historical Society for use in this study. These were produced over a period of about 20 years, from the mid-1980s to about 2005, and they reveal something of the history of raw material identification in the state during that period. The catalogs from the 1980s varied in quality, but most of the data from this period included large percentages of generic identifications (e.g., white and pink speckled chert). In the early 1990s, however, the percentage of generic identifications falls and the overall identifications become much more consistent. This consistency continues to the present.

This probably reflects the assembling of an extensive MHS raw material reference collection by the late 1980s, publication in the early 1990s of a number of new papers on raw materials in the state, and the fact that a number of archaeologists with different regional expertise in raw material studies and identification were working together at MHS beginning around 1990. By about the mid-1990s, the lithic raw material data generated both within and beyond the Historical Society appears to be generally consistent and dependable.

Sample Size and Site Characterization

The size of lithic assemblages used in this study varied from a single piece to many thousands of pieces. A sample of a single flake is obviously not adequate to characterize the raw material use patterns at the site – unless of course that flake is the entire lithic assemblage. Even in a case where a site contained only two raw materials, a sample size of one would be inadequate to reveal the presence of two materials, much less their relative percentages of occurrence. Similarly, it seems clear that a sample of several thousand pieces provides an adequate sample from a site. Given that there are at most three to four dozen materials that are likely to occur at a site, a sample of several thousand pieces should be adequate to reveal the presence of a raw material that occurs at a level of only 0.01 percent.

What is not immediately clear, however, is the size at which a sample may be considered adequate in a practical sense. Samples commonly range from a few tens of pieces to a few hundred pieces. Where in this range is the threshold at which a sample is probably adequate to characterize the total set of lithic artifacts that it represents?

There are two ways to approach this question. The first is to examine the statistics of sampling from a theoretical perspective. The second is to look at actual data, specifically data from sites where multiple collections – of varying sizes – have been made, but where the overall sample size is large. These two approaches give somewhat different answers.

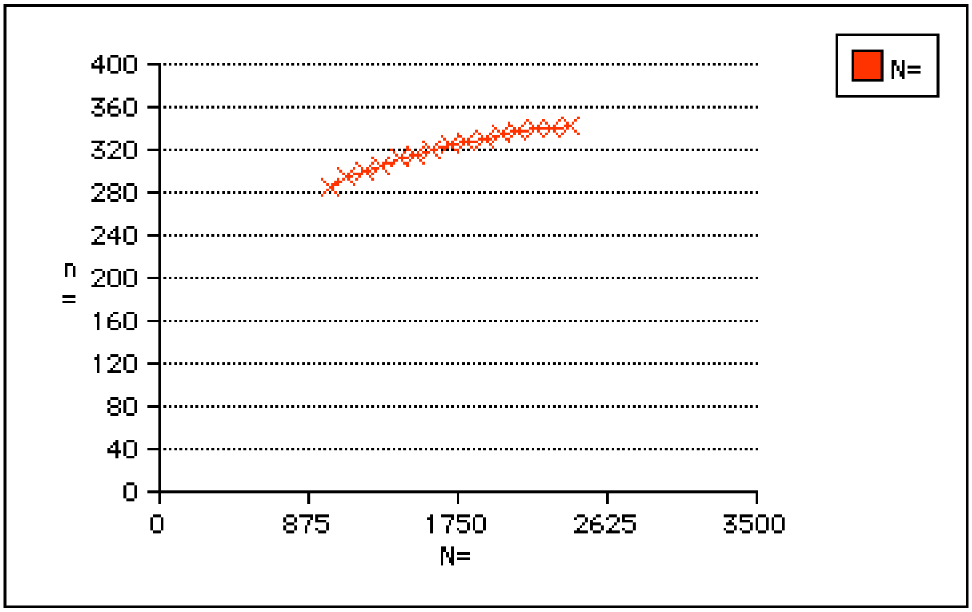
Statistical Considerations

The question of adequate sample size can be examined by using a statistical model to explore theoretical aspects of sampling (J.M. Richard, personal communication 2001). For the sake of simplification, Swan River Chert (SRC) is arbitrarily used as a representative raw material in the following discussion. The sample used here revolves around a formula that has five terms. "N" is the total "true" population (or the total set of lithic artifacts at a site), while "n" is a sample from the total population (or the lithic assemblage actually collected from the site). "Proportion" is the percentage of pieces in the sample that have a particular trait (or the percent of SRC in the assemblage). The confidence interval, set to 0.05, is the range in which you can make a statement about the proportion of "N," based on the known facts regarding "n" (or the range of variation between the actual percentage of SRC at the site and the percentage or SRC that will be seen in the collection, with an acceptable range of variation set to 5 percent). "Alpha," set to the standard figure of 0.05, is the probability of the random event that the sample is not representative of the population (or a 5 percent chance that because of random variation in the sample, the proportion of SRC in the sample will not represent the proportion of SRC at the site).

Using a spreadsheet, it is possible to run multiple iterations of the formula to address the following question: If we assume the site population is N, and we want to make a statement about the proportion of SRC in the population, and we accept a range of 0.05 around the proportion, and are willing to accept a 5 percent possibility of random error, what is the minimum number of artifacts (n) we must actually have in our collection to make this statement.

The spreadsheet allows us to vary the values of both "N" and "n," and look for the point where the confidence interval reaches 0.05. For example, if we set "N" (total number of lithic artifacts at a site) to 1000, we can run the formula multiple times with incrementally increasing values of "n" (collection size). In this case, the confidence interval reaches 0.05 at a sample size of about 286 artifacts. According to this model, therefore, at a site containing 1000 lithic artifacts, the percentage of SRC in a sample of 286 pieces will be within 5 percent of the actual percentage of SRC at the site, with no more than a 5 percept chance that random sampling error will give us a sample with a different percentage of SRC.

Figure 2-1. Graph of partial results from the statistical model exploring adequate sample size for different-sized site populations.



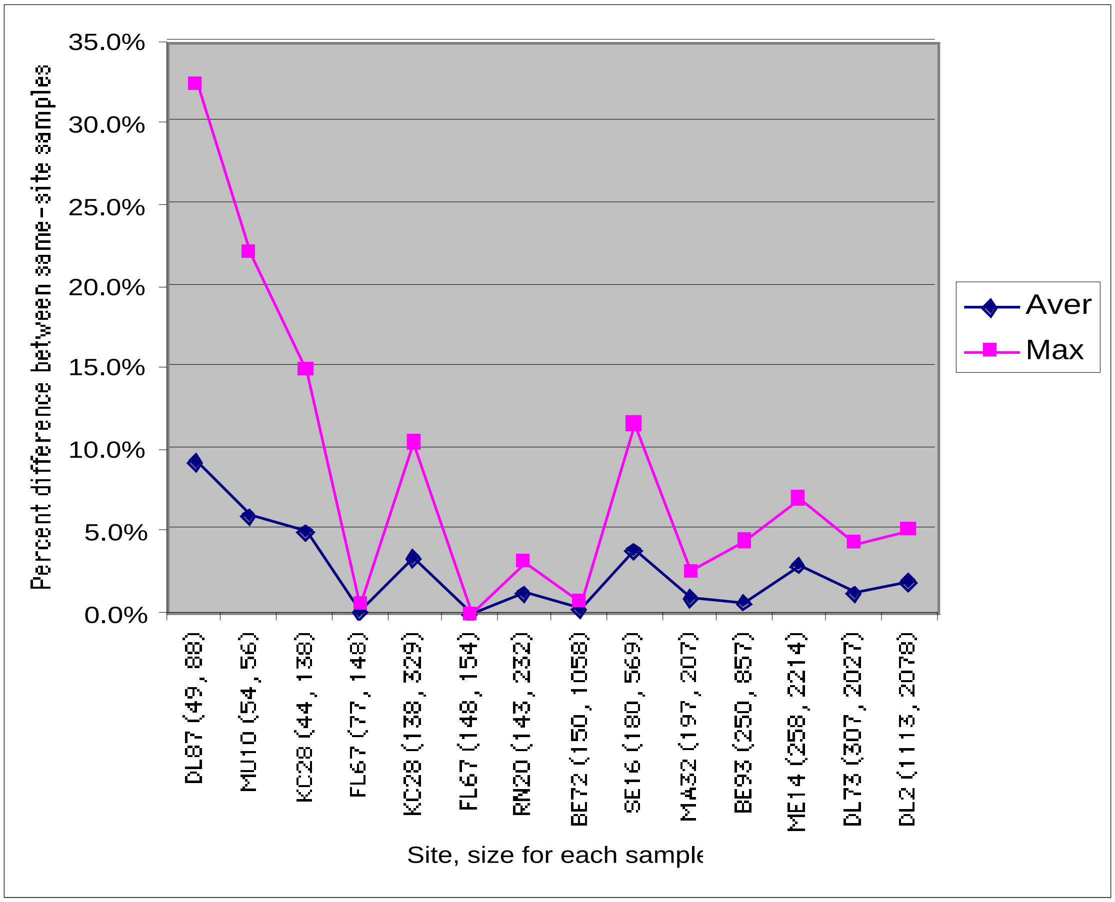
This can be repeated for different values of N (or different size sites), to produce the results shown in Figure 2-1. Note that the slope of the curve flattens as the size of the population increases. In other words, size of the required sample increases more slowly than the size of the site population. Once the site population climbs above 2,000 artifacts, the size of the required collection (or sample) quickly levels off around 340 artifacts.

This model does not account for all of the variability in the characteristics of a lithic assemblage, but it does provide helpful insight on the dynamics of sample size. The model is interpreted to suggest that a sample size of 300 to 350 pieces is probably adequate to characterize the total lithic assemblage from a typical site, with a reasonable degree of confidence.

Behavior of the Data

In addition to such statistical exploration, we can also approached the definition of adequate sample size by looking at the behavior of the lithic data. The most useful data for this comes from sites with multiple collections. The sites for this examination were chosen with a preference for identifications done by one researcher (or one team of researchers) during a

Figure 2-2. Average and maximum differences between multiple samples from a site, smaller to larger samples.



restricted time period. This is because some variation might be expected in raw material identification by different researchers or even for one researcher over time. Sites were also excluded from this consideration when it appeared that the variation might result from sampling different parts of the site, or when the samples represented different components. Sites with a number of very small samples were not considered, as it is already clear that small samples will vary considerably.

Unfortunately this leaves a rather limited group. The results clearly do not represent a real analysis of the behavior of sample size, or "prove" that a certain sample size is adequate to characterize a site. The results do, however, provide some clues to the behavior of sample size.

Figure 2-2 shows intrasite variability for 26 collections from 12 sites (see also Table 2-2). The figure requires a brief explanation. At site 21DL87, for example, the greatest variation occurs in the percentage of materials from the South Agassiz region. The smaller sample (n=49) has 65.3 percent of these materials, while the larger sample (n=88) has 33.0 percent. The difference between these figures, 32.4 percent, is plotted on the graph as the maximum variation. The variation for all categories (West Superior materials, Hollandale materials, TRS, quartz, etc.) is also averaged, to produce the second set of points shown on the graph. The sites are shown in approximate sample-size order, increasing to the right.

Table 2-2. Selected sites used to construct Figure 2-2, with information on collection sizes and differences in raw material profile percentages.

Site	Smaller Collection	Larger Collection	Maximum Difference	Data Source
21DL87	49	88	32.4%	MHS 1991-159, 1991-11
21MU10	54	56	22.0%	MHS 1994-190, 1995-206
21KC28	44	138	14.9%	MHS 1996-496, 1998-388
21FL67	77	148	0.6%	MHS 1991-154, 1991-23
21KC28	138	329	10.5%	MHS 1998-388, 1998-390
21FL67	148	154	0.0%	MHS 1991-23, 1992-131
21RN20	143	232	3.2%	MHS 1985-52, 1988-41
21BE72	150	1058	0.7%	MHS 1988-53, 1988-378
21SE16	180	569	11.6%	Murray 2000; Forsberg et al. 1999
21MA32	197	207	2.5%	MHS 1992-187, 1998-13
21BE93	250	857	4.5%	MHS 1991-45, 1993-304
21ME14	258	2214	7.0%	MHS 1991-294, 1993-132
21DL73	307	2027	4.3%	MHS 1988-389, 1990-25
21DL2	1113	2078	5.1%	MHS 1992-410, 1996-229

MHS = Minnesota Historical Society (accession number)

Note that there is considerable variation when the smaller collection includes fewer than 100 pieces. The degree of variability between collections *generally* decreases as the size of the smaller collection increases, although some variability remains even for the large collection sizes. This might serve as a reminder that sample size is not the only source of variation between different samples from a single site.

Note also the case of 21FL67. The lithic assemblage at this site is much more homogenous than is true of the other sites listed in the table. The figure and table look at three collections from this site (n=77, 148, 154). There is minor variation between the collections of 77 and 148 pieces, and almost no variation between the collections of 148 and 154 pieces. Sample size seems less important given such homogeneity, and even the smallest sample produces almost the same profile as the larger samples.

The data from these sites suggest a number of working hypotheses, useful for guiding analysis but subject to closer investigation. First, samples of fewer than 100 artifacts are unlikely to produce reliable profiles. Second, samples of about 150 or more pieces appear to provide reliable profiles in many cases. Third, larger sample sizes do not eliminate variation, and other potential sources of variation need to be considered. Fourth, more homogenous lithic assemblages can be adequately characterized by smaller samples.

One other effect of sample size on profiles should be noted. A sample of some certain minimum size, say 150 artifacts, may be adequate to provide a dependable general raw material profile for a site. The same sample might not, however, be large enough to reveal the presence of a rare raw material. Take obsidian as an example. At Minnesota sites containing obsidian, the material occurs at an average rate of fewer than three pieces per thousand lithic artifacts. Imagine a hypothetical site that contains obsidian with this frequency (2.765 pieces per thousand). A random sample of 362 lithic artifacts from the site should contain one piece of obsidian. A random sample of 181 pieces, however, has only one in two chances to contain a piece of obsidian. A sample of 90 pieces has only a one in four chance of revealing the presence of obsidian. A look at the data reinforces this idea. Although obsidian is seen in samples as small as 44 pieces, the sample size for assemblages containing obsidian averages 1511 pieces and ranges up to 5348.

What might be called a "numerical" problem also surfaces with samples of fewer than 100 artifacts. For a sample of exactly 100 pieces, each piece contributes 1 percent to the profile. For samples of more than 100 pieces, each piece contributes less than 1 percent. But for samples of fewer than 100 pieces, that figure is above 1 percent. For these smaller samples, the numbers in a raw material profile jump by increments of more than 1 percent, and the profile is less capable of showing subtle variations. With a sample size of 20 artifacts, for example, the profile can only change in increments of 5 percent.

General Working Guidelines

In summary, this discussion does not provide precise guidelines when it comes to deciding how big a sample is needed before that sample provides a dependable raw material profile for a site. Thus it seems we must settle for a set of general working guidelines until better answers can be found. First, profiles based on a sample of fewer than 100 lithic artifacts should be used with caution. Second, profiles based on a sample of about 150 artifacts probably present a good picture of raw material use at the site, although there is the chance that rare materials are being missed. Third, profiles based on a sample of about 300 pieces or more should provide a dependable profile and also provide a good chance of detecting rare raw materials. Fourth, a site with a relatively homogenous population of lithic artifacts can be adequately profiled by a smaller sample.

In practice, for this study it has been necessary to use profiles derived from most samples of 100 or more lithic artifacts in trying to characterize raw material use patterns for different regions and time periods. Relatively few sites yield large lithic samples. Of the approximately 1,200 Minnesota sites included in the sample, around 200 have both good quality data and a sample size of 100 or more lithic artifacts. In a few cases, samples of fewer than 100 pieces have even been included in the set of analytical profiles. An example is 21PL54, which had only 93 pieces but represented a restricted, dated Middle Woodland component. Even with the addition of such selected smaller samples, the total number of profiled sites remains near 200.

This is a relatively small number of sites to support the exploration of raw material use patterns across the state over the course of 13,000 years. Consider the case of seven regions or subregions, and four general use patterns. If the sites were evenly distributed by region and use pattern, each region/pattern would be represented by only seven or eight sites. This does not even consider other factors like functional variation. Thus the samples of 100 or so artifacts have been included in the analysis, with the precaution of realizing that this may introduce extra fluctuation into the percentages presented in the profiles and thus make it more difficult to define the essential characteristics of a particular raw material use pattern.

Finally, note that these same sample-size guidelines and general "thresholds" can also be applied to aggregated samples. For example, because counties are a central element in how archaeological data is reported and organized in the region, this study often looks at total lithic sample by county. Based on the guidelines discussed above, the sample of over 10,000 pieces from Marshall County is adequate to represent raw material use patterns in that area.

The sample of three artifacts from Lake of the Woods County, however, is not adequate. The same is true for various aggregations of data by time period, cultural association, or other factors.

Typicality of Sites

Raw material use patterns represent typical behavior, or the average of a variety of activities carried out over a period of time. A site that represents a variety of activities therefore provides a better look at an overall raw material use pattern. Such a site is typical of the raw material use pattern. Some sites, however, are not typical.

The "ideal assemblage" for this analysis is one that represents the full range of activities that were associated with a given lithic economy – and therefore with the raw material use pattern that represents that economy. This might include, for example, different technological stages from raw material procurement to reduction, tool use, maintenance, and discard. It might also reflect changes across seasons or between sites with different functions. In contrast, a lithic assemblage from a site that represents only a small part of the full spectrum might provide information that is useful for looking into the inner workings of a raw material use pattern, but that is not representative of the full pattern.

The ideal assemblage also represents only one raw material use pattern. For example, a site that was used repeatedly by Middle Woodland groups probably presents a good average look at raw material use patterns during the Middle Woodland. In contrast, a site with mixed Archaic and Woodland components yields an assemblage that represents neither Archaic nor Woodland raw material use patterns, and the resulting data set is not particularly useful in sorting out the history of raw material use in the region.

While many factors no doubt influence the character of an assemblage, only a small number of factors have an obvious effect on the typicality of lithic assemblages. These are discussed under the categories of site function and duration of site use.

Site Function

We could expect that sites with different functions could display different raw material signatures. Within a single culture and time period, for example, a ricing camp might have a different profile than a bison processing site or spring fishing camp. The degree to which this is actually true is hard to determine, however. To date, most of the observed variation seems to relate to geographic location and broad technological patterns that are associated with general chronological trends, rather than specifics of site function. Future research might profitably examine the degree to which site function affects the expression of a lithic raw material use pattern.

There is one case, however, where site function can clearly affect the raw material signature. This involves a raw material procurement site that offers one kind of raw materials (i.e., a primary or bedrock source rather than a secondary or glacial source). Examples include Silver Mound, a large outcrop that is the source of Hixton Quartzite, and the Bass site, where Galena Chert was gathered from lag deposits. This issue is dealt with separately, however, in connection with raw material distributions and the idea of primary source region "hot spots." Using this approach, we can separate provisioning from other site functions and hopefully have a clearer field for future analysis.

Note that this not a concern at sites with a broader range of functions, only one of which was raw material procurement – a situation that appears to be fairly common. While it might be desirable to separate procurement-related data within such sites, this is simply not feasible. In addition, such more-or-less opportunistic raw material gathering is simply not as intensive as the activity represented at a site like Bradbury Brook; the resulting numbers therefore do not overwhelm the rest of the data.

Duration of Site Use

The duration of site use can also affect how typically a site represents a given raw material use pattern. This can be true for either very brief or very long site use.

A site that was used very briefly and only once – overnight for example – can reflect such a small sliver of overall raw material use that it is not typical of the associated raw material use pattern. Basswood Shores (21DL90) provides a good example. Excavation in the northern part of the site sampled a "small, localized, single component site area that was used for a short duration" (Justin and Schuster 1994:79). The sample included 902 flaked stone artifacts of which 838 (92.9%) were Maynes Creek Speckled Chert, a raw material from central Iowa. These data certainly have interesting implications about connections between central Iowa and west-central Minnesota in the late prehistoric or early Contact period. The resulting raw material profile is not, however, representative of the pattern seen at other late prehistoric sites in the region. In fact, the rest of the statewide data set includes only 24 other pieces of Maynes Creek Chert, indicating a much more modest role for this material than the Basswood Shores data would suggest. A second example comes from the Erickson site (21RO21), where a short-duration Laurel site yielded 561 lithic artifacts of which 549 (97.9%) were Knife River Flint (Bakken 1988). In both cases the lithic assemblage probably represents work on a few tools.

A site that was used repeatedly over a long period of time can also present a profile that reflects more than one raw material use pattern and thus is not typical of any single pattern. This is often the case in desirable locations with little to no sediment deposition, so that for centuries to millennia activities took place on a stable land surface and the artifacts from multiple components became mixed. It is also seen at sites like Cedar Creek (21AK58), where turbation of sandy soils mixed components ranging from Paleoindian to Woodland (Allan 1993). Equivalent results can even come from excavation of stratified sites in a depositional environment. At the Femco site (21WL1), for example, excavation encountered stratified archaeological deposits in a swell-and-swale landscape on the inside of a Red River meander. The swell-and-swale stratigraphy was so complex and variable that it defied attempts to correlate stratigraphy between units (Fie 1986).

MANIPULATION OF THE DATA

To some extent this study relies on examining and comparing the characteristics of individual assemblages. But the search for broader patterns also requires looking *beyond* individual assemblages. In part this is because larger, better-understood assemblages constitute only a fraction of the total available data. Many of the data, for example, come from small assemblages. A small assemblage may not bear much – or any – interpretation by itself. It still represents part of the overall picture of raw materials use, however, and combining it with related assemblages captures that part of the overall pattern. In addition, many of the assemblages – small or large – come from sites that are not well understood, whether in terms of chronology, cultural associations, or other factors. Thus it does not seem productive to spend much effort on individually analyzing such assemblages, but neither does it seem productive to ignore the information they could provide. Data aggregation provides a way to include such assemblages in the overall picture of raw material use.

In addition, we might expect that an individual assemblage can vary somewhat from the overall pattern of raw material use (as discussed above). At the beginning of this research, however, it was not clear to what degree this is true or how much variation we might expect. Looking at the data in aggregate gives us a way to determine "average" use levels of different raw materials, and so establish a series of benchmarks that can help us assess the level of variation between sites.

Because of the data quality issues discussed above, and because of the presence of atypical assemblages, it was also necessary to segregate some data. This data could then be retained as part of the overall sample and selected data points could be extracted, without the problematic assemblages obscuring patterns more clearly expressed in other assemblages.

On the technical side, data were stored, manipulated and analyzed in a series of more than 100 dynamically linked (i.e., self updating) spreadsheets rather than in databases, since the spreadsheets provided a better and broader visual perspective on the data. Graphing and GIS mapping were also used to explore and display the data.

Data Aggregation

The basic idea of aggregation is simple: data from a set of related assemblages are added together, producing a larger sample that represents some particular condition, like the data for all sites in Houston County or all Late Archaic sites. Aggregation helps achieve multiple goals: to make use of the information provided by small samples; to create samples of some condition that are large enough to support some meaningful analysis; and to smooth out variation between assemblages.

As noted, sample size per assemblage varied from a single piece to many thousands of pieces. Even the very small samples were included in the study because, although they alone might not support any meaningful analysis, they are still part of the overall patterns of raw material use. Small samples are really only useful, however, if they can be aggregated with other data sets. The sample size conditions discussed above are taken to pertain not only to individual assemblages, but also to aggregated assemblages. For example, at one point the sample for ceramic assemblages in Todd County included five sites, with sample size ranging from 25 to 57 pieces. None of these assemblages reached the threshold to provide an adequate characterization of the raw material use pattern in this restricted area during the ceramic period. However, aggregating the samples produced a total Todd County ceramic-period sample of 165 pieces, which was large enough to support analysis.

A variety of ways were explored to aggregate the data, and a few proved to have some analytical utility. Appropriately enough for an archaeological analysis, these were essentially the equivalent of locating the data in time and space, then grouping neighboring samples.

Geographic aggregation proved fairly straightforward and yielded good results, in part because of very good spatial control for almost all the data. Although sites were treated as single points in this study – deemed more than adequate on a statewide scale – most sites in fact have clearly mapped boundaries, and in many cases the locations of individual artifacts within those boundaries is known to within a meter or less. Chronological placement and aggregation proved to be more problematic, in part because many of the sites represented in the data lacked good chronological information. It was possible, however, to achieve satisfactory results based on the available chronological information.

Note that this "chronological" aggregation actually combines site chronology and cultural affiliation. This combining seemed inevitable, and woven into the data set. A few sites or components have absolute dates, but many more have relative dates based on typological information. And typology, of course, is linked to characteristics that to one degree or another represent different "cultures." This combining of site chronology and cultural affiliation could probably be avoided given an abundance of radiocarbon (or other absolute) dates, although this would probably not substantially alter the overall results.

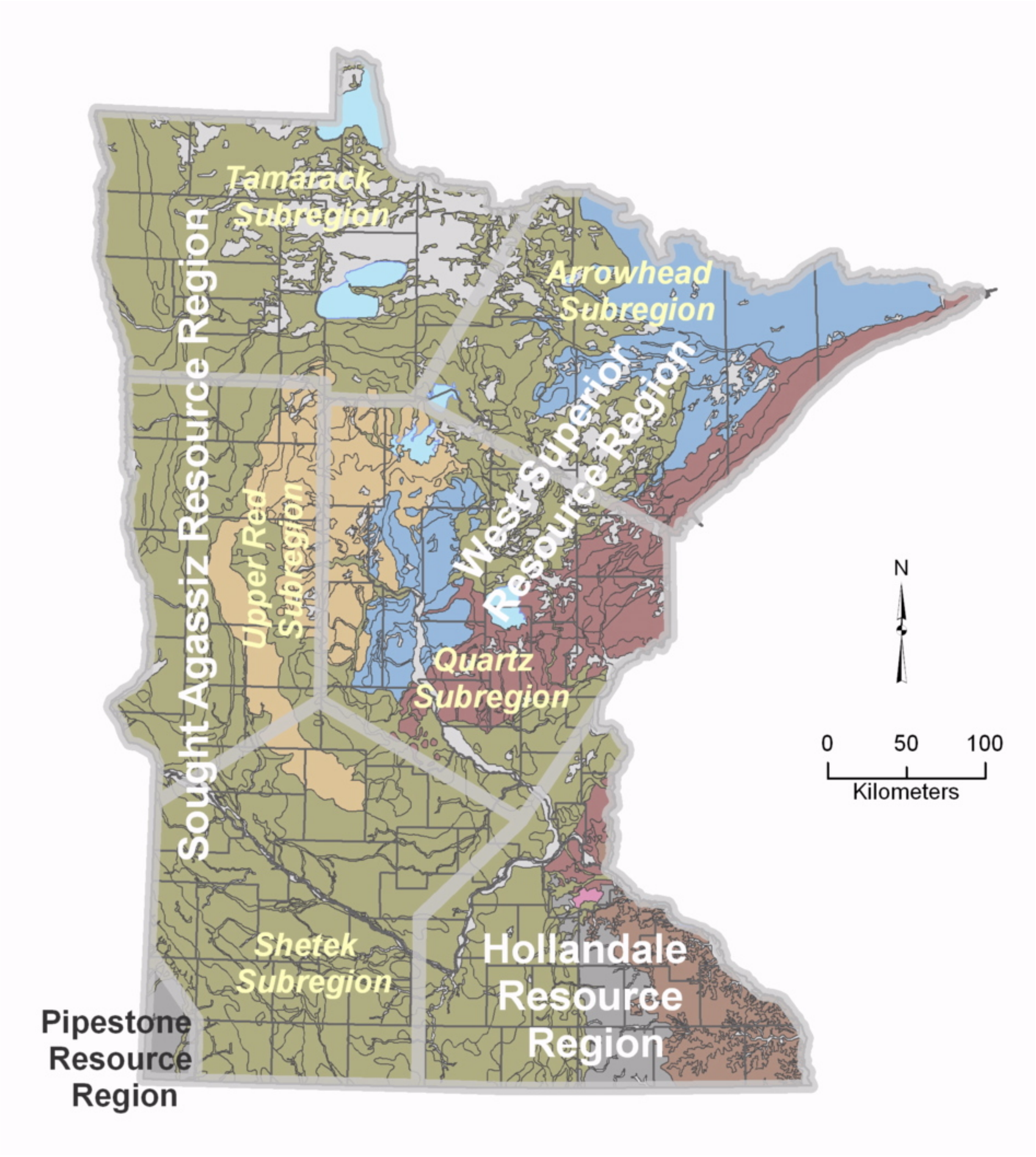
Other factors might also prove useful for aggregating site data, and some were considered or explored. Site function provides one example – grouping data from bison kill sites, for example, or ricing camps. In practice, site function is not well defined for most sites, which precluded wide use of this method. This discussion mentions a few techniques that were considered or tried, but ultimately not used. They are mentioned in part as possible avenues for further research, and in part to explain why they were not pursued at this time.

Geographic Aggregation

The data were aggregated on various scales, including statewide, regional, subregional, by county and – in selected circumstances – in ways that cross-cut some of these usual boundaries. Statewide totals provide information on questions like the relative importance of various raw materials, data set statistics, and to a limited degree variation between the different states and provinces included in this study. The best information on regional variation in raw material use patterns, however, comes from the smaller-scale aggregations.

Data were aggregated by raw material resource region using the four regions defined in Chapter 3 (South Agassiz, West Superior, Hollandale, Pipestone; Figure 2-3). This provided essential information on similarities and differences between assemblages over broad areas,

Figure 2-3. Lithic raw material resource regions and subregions in Minnesota, compared to generalized Quaternary geology (after Hobbs and Goebel 1982; green shows Des Moines or Red River lobes, gold shows Wadena lobe, blue shows Rainy lobe, red shows Superior lobe, grey shows old tills, brown shows areas not recently glaciated).



and also on central tendencies within regions. It should be noted that the process of assigning blocks of data to various regions helped to refine regional boundaries (although these still remain intentionally approximate), and revealed some areas of transitional character that could not be clearly assigned to one or another region.

In the case where subregions were defined (South Agassiz, West Superior), the data were also aggregated by subregion. This provided information on important variations with the larger regions, both in the resource base and in raw material use patterns.

In all of these cases, sites were not handled individually but were grouped in blocks of data by county. Counties represent (in most cases) the finest scale geographic units that were studied in aggregate. For example, all of the (better quality) data from a county could be aggregated. The resulting tallies and percentages could be taken as an overall average of raw material use patterns in that county (ignoring for the moment the matter of distribution through time). This could be repeated for each county. Then the relative occurrence of some factor – the percentage of Tongue River Silica, for example – could be mapped for each county. The result is a map with large pixels (counties) and relatively coarse resolution, but a map that provides a wealth of useful information on statewide raw material use patterns.

Initially the data were aggregated and mapped by county as an expedient measure, since sites are recorded and numbered by county, and information including reports is filed by county. Of course there are obvious objections to giving counties such prominence in how data are handled. The modern geopolitical boundaries of a county, for example, are irrelevant in the precontact period (with the possible exception of some boundaries that follow natural features such as rivers or lakeshores). Further exploration of the data, however, suggested that this irrelevance may be in some degree advantageous since county boundaries are in a sense neutral in regard to the data, and that displaying data by county is not an unreasonable method.

Another attempt was made to aggregate and analyze data by surface geology, with the intention of mapping the data by these units. Each site was assigned to a surficial geological unit, as specified in a GIS layer distributed by the Minnesota Geological Survey. Data were then aggregated according to whether sites were located on a deposit of, for example, the Erskine Moraine of the Des Moine lobe or the Alexandria Moraine of the Wadena Lobe.

The results were unexpected. The earlier mapping (by county) had shown that cultural raw material distributions appeared to closely mirror natural raw material availability, suggesting that sites on different glacial sediments should have distinctly different raw material occurrence. Instead this second analysis showed that within a county, sites on sediments of different glacial origin showed relatively little difference in occurrence and proportions of raw materials. This suggests two things. First, sites on average reflected raw material procurement over a region broad enough to include materials from more than one kind of glacial sediment – at least in regions where multiple sediments are present. (This conclusion is discussed in greater detail in Chapter 3.) Second, aggregating data by surface geology will not generally be a useful aggregation and mapping technique. Upon further reflection, it also became apparent that the surface geology units were of such variable size and irregular shape as to be a poor choice for projecting the lithic data.

On the other hand it did suggest that, at least in part, counties might prove after all to be a useful if crude choice for mapping data. The counties in general appear to be larger than the size of raw material acquisition areas (of as yet unknown size). This, taken with the irrelevance of these boundaries in the precontact period, means that they could provide a useful and "neutral" way of providing an "average" look at raw material use patterns. This is probably most satisfactory in southern Minnesota, where most counties are about the same size and shape. It is obviously a problem in northeast Minnesota, where the counties vary a great deal in size and shape; the enormous St. Louis County is a distinct problem. On the whole, however, the method has some merits and is also expedient since it reflects an underlying organization of the modern data. The drawbacks could be partly mediated by subdividing some of the larger counties or counties straddling two distinctive geological regions.

Chronological Aggregation

Chronological placement and aggregation proves to be more difficult than geographic aggregation. Chronological issues have in fact proven to be a major challenge in this analysis. While most collections have good geographic control, few have adequate chronological control. Absolute dates are not common, relative dating is not well controlled, and many sites have (or may have) multiple components.

The analytical approach has therefore consisted of finding proxies – characteristics of a site that can help place it within some broad chronological division but not effectively dating the site. One of the first attempts to do this, for example, involved separating ceramic sites from aceramic sites. This approximately divides the sites into a Paleo-Archaic category and a Woodland-Village cultures category. These can be further divided. Many Paleoindian sites can be recognized by the presence of distinctive lanceolate points. These sites can be removed from the aceramic sample, and the remaining aceramic sample will better represents the raw material use patterns of the Archaic – albeit still combining Early, Middle and Late Archaic.

This kind of method will not, of course, identify all Paleoindian sites in the aceramic sample. Similarly, some ceramic-period sites may not contain ceramics, or the ceramics may be sparse and not represented a particular collection from the site. In the latter case, projectile point typology occasionally allows identification of an aceramic site from a ceramic period, but this is not always the case.

A set of related problems also occurs. There could be sites, for example, that have a predominantly Archaic lithic assemblage plus a small Woodland component that includes a few ceramic sherds. Or a site might have horizontal separation of ceramic and aceramic components, but the site report does not contain enough information to separate the lithic data by component. And many sites of course, especially in intensively-used landscapes like that around Mille Lacs Lake, are used for millennia and contain intimately mixed components representing multiple raw material use patterns.

The response seems is to include such assemblages in a "other/multiple" category, which allows them to be accounted for but not aggressively analyzed. It also prevents them from further clouding results that may already lack the desired focus. The price for this further data segregation is that some of the aggregated samples are therefore too small to support meaningful analysis; the price seems unavoidable, short of returning to the original site documentation in case after case and reanalyzing the site in a way that better supports this kind of analysis.[1]

A further step in attempting to unravel chronology and raw material use patterns involved comparing the characteristics of individual assemblages (see discussion of raw material profiles below), and grouping those that were similar. In the quartz subregion, for example, sites with less than 50 percent quartz, a moderate percentage of West Superior materials, and a few percentage points of Tongue River Silica might be grouped together. Sites with more than 50 percent quartz and a low percentage of West Superior materials might be placed in another group.

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1. Such reanalyses – even of a few key sites – would probably be very productive in terms of testing and refining the model presented in this paper. This, along with new radiocarbon dates on archived samples and recataloging of older collections using current raw material identifications, are all recommended as future research opportunities with potential to greatly improve our understanding of raw material use patterns in this region.

In itself this step provides no new information on chronology. Sites within each group might, however, provide chronological clues. If several of the low-quartz sites appeared to be Archaic, this might represent an Archaic-period raw material use pattern. If in addition many of the high-quartz sites appeared to belong to one or another part of the Woodland period, the possibility increases of finding a real distinction in Archaic and Woodland raw material use patterns.

A similar example from the Red River Valley involves the relative abundance of Knife River Flint (KRF). Some Late Archaic components from that region have remarkably high percentages of KRF. This suggests an intensification of KRF circulation during the period, and possibly also a geographic expansion of distribution. If KRF distribution expands in the Late Archaic, then it could be helpful to separately examine aceramic sites without KRF and aceramic sites with KRF. Potentially this could represent a separation of Early to Middle Archaic sites from Late Archaic site, at least in parts of the state reached by KRF. Obviously this kind of analytical stretch needs to be examined in the light of other lines of evidence. The advantage, however, is that this produces a hypothesis that can be tested. Similar strategies were pursued in other parts of the state, based on comparable factors.

In sum, the overall geography of raw material use patterns is fairly clear. Chronological patterning, however, is more difficult to determine, and extended analysis is required to begin to tease apart the chronological strata in the geographic patterns.

Data Segregation

Data segregation simply refers to entering data for selected assemblages into the standard data spreadsheets, but not including the assemblages in tallies such as statewide or regional totals, totals for particular periods, and so on. This also means that the segregated data were not mapped. This was necessary in only a limited number of cases.

Segregation Based on Data Quality

Variable data quality was addressed by segregating weaker quality data, so that it was not included in aggregated totals. In this way the aggregated numbers would not be colored by generic identifications, suspect identifications, and so on. The weaker quality data sets were still on hand, however, and could be consulted. Note that such data sets can still provide some useful information, such as counts for more readily recognized raw materials like quartz or Knife River Flint.

Segregation Based on Site Characteristics

The data from some kinds of sites were also segregated from the general data set in order to avoid skewing the overall analysis. Initially these included large lithic procurement sites and very brief duration sites. As the research progressed, it became increasingly clear that generally atypical assemblages needed to be segregated from some totals, even if it was not clear why an assemblage was atypical. As in other cases, this was done to keep the atypical data from obscuring the general patterns seen in most other assemblages.

Large lithic procurement sites were segregated when the sample consisted almost exclusively of one raw material, and when the very large sample size would skew aggregate totals in favor of that raw material if the data was included in general counts. Bradbury Brook, with more than 125,000 pieces of Knife Lake Siltstone, provides an example. Data from procurement sites were only segregated when the procurement function was clearly predominant over other functions. Sites were not segregated in cases where raw material procurement was one of several activities. It is also possible that some low-intensity procurement sites may have been overlooked. It is unlikely, however, that this significantly skewed the data since it involved smaller numbers of artifacts.

Very brief duration sites were also segregated from the general data set when they were recognized. This was also done to avoid skewing the overall sample in the direction of atypical samples that represented a small range of activities, often over-representing one raw material. Sites were usually included in this category based on the interpretations by the original researchers, but in some cases based on my own re-evaluation of the artifacts and documentation. It is likely that data from some brief-duration sites were not segregated, but this was in cases where the data did not look atypical. Thus the inclusion of these data in the general data set made no appreciable difference.

TERMINOLOGY

This section discusses selected terms that are used in a nonstandard way, that do not have a consistent definition, or that are defined or redefined for the purposes of this thesis. It does not include terms that are specific to the resource and use-pattern models. Those terms are discussed in the presentation of the models.

Geological Terms

Whenever possible, the use of geological terms conforms to standard or common definitions used in that field. In some cases, however, alternative uses are well established in archaeology. The main relevant example here is the term silicate. In archaeology, silicate is used in the sense of a stone that is rich in silica. It is synonymous with the geological term siliceous rock, rather than silicate in the geological sense.

It is also worth noting that rock types (specifically as used in raw material names) are not used as precisely in archaeology as in geology. This is particularly the case when terms are used in a generic and descriptive sense. Archaeologists, for example, frequently use the term chalcedony for translucent siliceous rock with a fine grain and pronounced waxy texture. Mineralogically, in contrast, the term refers to siliceous rock with a fibrous crystal structure.

Such lack of geological precision, however, does not need to pose a problem. Geologists have a finely articulated vocabulary which they use to certain purposes. The goals of archaeologists, however, are usually quite different so the less-precise use of geological terms does not interfere with archaeological goals as long as it is clear how the term is being used.

Raw Material Profiles

One of the analytical tools developed as a part of this research is the "raw material profile." I have used this approach in a number of previous reports (e.g., Bakken 1995b, 1998), and it has also been used by other researchers (e.g., Gonsior et al. 1996). The idea has not, however, been explicitly defined, so the following paragraphs attempt to provide such a definition.

The previous reports tended to use two basic profiles. One simply listed raw materials by percentage of the total lithic assemblage. The other used a set of categories that clustered raw materials using a mix of geographic (e.g., Western Resource Region, exotic materials) and technological (e.g., chopping tool materials) criteria.

I would suggest that the previous case should simply be called a raw material inventory. The lithic raw inventory material is simply a list of various raw materials by percentage of the total lithic assemblage, plus a category called "unidentified" that includes any pieces identified only to a generic level. The "unidentified" category would include entries for generic categories such as agate, burned chert, chalcedony, chert, fossiliferous chert, jasper, silicate, and unidentified rock. The use of this category is optional because in some cases it may be informative to list these categories individually to facilitate comparison between sites, and so on.

The raw material profile begins with the inventory but then groups raw materials in a way that facilitates analysis. Raw materials are generally associated by geographic origin, including as raw material groups when applicable. Table 2-3 provides a suggested standard for grouping raw materials, and the method that is used in this thesis. Note that these groupings embody a particular view of the origins and distributions of the various raw materials. Researchers who hold a different view might chose to associate raw materials in a different way. This is, of course, perfectly acceptable, but I would suggest that in such cases it would be helpful for the researcher to specify how materials are grouped as well as provide the rationale behind the groupings.

Note that in this thesis, there are four cases where the association of raw materials has no real geographic basis. These cases are exotics, quartz, chopper materials and generic identifications. The exotics could easily be distributed by geographic origin. In the remaining three cases, the raw materials are either widely distributed (quartz, chopper materials) or have poorly known distributions (generic identifications). And in contrast to designations for the other groupings, "chopper materials" references a functional category. This was deemed appropriate, however, since 1) the primary basis for defining the group is widespread (inter-regional) distribution, and 2) the materials are not part of the general flaked stone economy, and are used in a very specialized fashion (unlike most of the other raw materials, which are used in multiple ways).

It is important to note that a profile must include every piece in a lithic assemblage.[2] It is not allowable, for example, to only include raw materials with known distributions. This is the case for two reasons. First, it ensures that the resulting percentage figures represent percentage of the whole assemblage; adding up all the percentages in a given profile produces a result of 100 percent (not considering rounding error). This produces data that are directly comparable between sites, regions, et cetera. Leaving out part of an assemblage changes the percent figures and gives results that are not directly comparable between profiles. Second,

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[2] More specifically, it must include all the flaked stone. Groundstone, carved stone and fire-cracked rock (FCR) should not be included.

Table 2-3. General categorizations of lithic raw materials used in analysis, discussion and data presentation.

Set *(geog.)*	**Raw Materials**	**Set *(other)***	**Raw Materials**
South Agassiz	Knife River Flint (*local*) Swan River Chert Red River Chert silicified wood	**TRS**	Tongue River Silica
Hollandale	Cedar Valley Chert Galena Chert Grand Meadow Chert Maquoketa Chert Prairie du Chien Chert Shell Rock Chert	**Border Lakes Greenstone Group**	Knife Lake Siltstone Lake of the Woods Siltstone Lake of the Woods Rhyolite BLG Group (*indeterminate*)
West Superior	Animikie Group •Biwabik Silica •Jasper Taconite •Gunflint Silica •Kakabeka Chert Fat Rock Quartz Hudson Bay Lowland Chert Lake Superior Agate other rhyolite	**Sioux Group**	Sioux Quartzite Sioux Conglomerate Jasper Sioux Conglomerate Quartz Sioux Conglomerate Quartzite Sioux Conglomerate Chert Sioux Conglomerate Iron Formation
Pipestone	Gulseth Silica	**Western River Gravels Group**	Moss Agate Black Hills materials ? other
Nonlocal (IA)	Fusilinid Group Maynes Creek Chert Warsaw Chert Moline Chert Keokuk Chert	**Exotics**	Burlington Chert Hixton Group Knife River Flint obsidian
Nonlocal (WI)	Marquette Rhyolite	**Quartz**	misc. quartz
Nonlocal (OT)	Nelson River Chert West Patricia Chert	**Chopper Materials**	basaltic rock granitic rock other chopper materials
Nonlocal (ND)	Ft. Union Porcellanite Grey Tongue River Silica	**Generic IDs**	agate burned chert chalcedony chert jasper quartzite unidentified
Nonlocal (SD)	Ogallala Group Black Hills materials ?		

every piece is composed of some raw material and every piece comes from some source area. This is true whether or not we identify the raw material or the source area. That it why the definition of each profile includes a category of "other" or "unknown."

Nonlocal and Exotic Raw Materials

It may help to clarify use of the terms exotic and nonlocal, since neither term has a standard definition. In this thesis, nonlocal is defined in terms of resource regions. A nonlocal raw material comes from a different region than the region a site is located in. The distance from the site to the source is immaterial. In the Upper Red Subregion, for example, Prairie du Chien Chert would be nonlocal, as would Maynes Creek Chert from Iowa and Alibates Chert from Texas.

Exotic is a subset of nonlocal – exotic materials are always nonlocal, but nonlocal materials are not always exotic. Exotic raw materials are typically of better than average quality, and often of high quality. It seems that they were more intensively quarried, and circulated over relatively large areas in significant amounts. (Note, however, that extent and intensity of circulation might vary over time.) In general it seems that the raw material sources provide large amounts of the exotic material, and probably also large pieces of the raw material. There are only four principal exotics found at archaeological sites in Minnesota. These are Knife River Flint, Hixton Quartzite, Burlington Chert, and obsidian. The latter is relatively rare, a fact that is probably related to the much greater distance to the source, but all four of the materials meet the conditions outlined above.

Other exotics probably occur, but only rarely. Note that determining which other raw materials might qualify as exotics under this definition would require additional research on the lithic resources of more distant regions. This research has not been attempted here, in part because the potential benefits would seem to be limited in terms of understanding raw material use in Minnesota and the Upper Midwest.

These definitions may require clarification or even reformulation at some point. It might be desirable, for example, to frame the definitions in terms of specific distances. It might also turn out that the definitions need to be different for different places. At the present, however, the above definitions seem serviceable, and in any case they may provide greater clarity than has previously been the case.

The circulation of exotic and other nonlocal raw materials is discussed in terms of two factors – extent and intensity. We might note, for example, the Paleoindian pattern of very extensive but very low intensity circulation of Knife River Flint. This contrasts with the Middle Woodland pattern of moderately extensive but very high intensity circulation of KRF. The combined use of these two terms allows for greater precision in discussion of raw material circulation.

Hierarchy of Raw Material Identification

A raw material identification can be more specific or less specific. Raw material identification can be thought of as a hierarchy having five levels: unidentified, generic categories, raw material group, specific materials, subvarieties. The top level includes categories such as "unidentified raw material" and "silicate," terms that convey remarkably little information. These can occasionally be useful when a raw material defies not only identification but even classification.

The next level contains a set of generic categories: chert, jasper, quartzite, et cetera. Such terms tell us a little about the physical characteristics of the material, but usually do not provide any information on place of origin, geographic distribution, or specific physical characteristics. The popular practice of adding descriptive terms does little to increase the information content. For example, many older catalogs include a large proportion of generic identifications such as "brown chert" or "grey-green speckled chert."

The third level includes terms like "Fusilinid Group" or "Animikie Group" (alternatively "Animikie Silicates"), which group together a set of related materials. These names reference definitions that include some information about region of availability and general physical characteristics, but less specific information than is typically provided by the next level of the hierarchy. Fusilinid Group cherts, for example, include a number of specifically defined, fossiliferous Pennsylvanian cherts from southwest Iowa and neighboring regions. The concept of raw material groups is discussed at some length in Chapter 3.

The fourth level includes such familiar names as Swan River Chert or Knife River Flint. Such specifically named materials are defined in terms of characteristics like appearance, flaking quality, geographic distribution, petrography, et cetera.

Finally, subvarieties are defined for some raw materials. For example, Cedar Valley Chert has opaque and translucent varieties (categories that have, incidentally, recently become obsolete). This is the most specific level of identification.

A note of caution is warranted: although this hierarchy is conceptually tidy, its application is anything but. In this thesis, for example, the generic category "quartz" can be applied to a material with known distribution and characteristics. The term obsidian, while arguably a generic category, is used in the sense of a raw material family. Prairie du Chien Chert is commonly used as a specific category, but some researchers use it as a "group" that includes Shakopee and Oneota cherts. Other examples could be cited.

Raw Material Diversity

Simply put, diversity is the number of classes represented in a particular archaeological assemblage. This might be, for example, the number of ceramic types in a ceramic assemblage, or the number of species in a faunal assemblage. In this case, it is the number of raw materials in a lithic assemblage. The data examined for this study seem to indicate that diversity varies in a systematic way in lithic assemblages, and that it is an important characteristic of raw material use patterns. Measuring diversity is difficult, however, given great variations in sample size between assemblages.

Kintigh (1989; see also Grayson and Cole 1998) provides a useful discussion of measuring diversity in archaeological assemblages, and presents methods for measuring this characteristic. A particularly helpful part of the discussion examines how diversity can be measured even in the face of sample-size variation. (Note, however, that I use the term "diversity" where Kintigh would more specifically say "richness.")

In simple terms, this method consists of graphing the sample size against the number of classes. A line representing the mean can be drawn through the plotted points. A band indicating a confidence interval is drawn along either side of the line. Points falling within the band have the "expected" degree of diversity; points falling above or below the band represent assemblages that are more or less diverse than expected.

The method seems to be helpful when applied to the lithic data, although it must be used with some reservation. The way that data were recorded, for example, or an analyst's failure to identify some raw materials, can disguise the true diversity of a sample. Also, very small sample size will still produce results that are not dependable. Given these and other potential weaknesses in the measure, it is used to produce only relative rankings of diversity. These are limited to more diverse than expected, as diverse as expected, and less diverse than expected. No attempt is made to further quantify the results, as this would certainly produce tidy but misleading results.

The measure still proves useful in pointing out general trends between different raw material use patterns. It might be possible to say, for example, that Paleoindian assemblages exhibit relatively low diversity compared to Middle Archaic or Late Woodland assemblages.

Other Archaeological Terms

Chronological discussions are generally framed in radiocarbon years before present, not calendar years. The designation BP (before present) should be understood to mean RCYBP (radiocarbon years before present). Although it is generally desirable to calibrate radiocarbon dates and use calendar dates, that is avoided here for two reasons. First, calibration is frequently updated and any calibrations reported here could soon be obsolete. When the uncalibrated dates are available, however, any researcher is free to derive up-to-date calibrations for more detailed study. In addition, in this thesis chronology is discussed in broad and approximate terms – in terms of the nearest 500 years, for example. Calibration would not substantially aid this discussion internally, although calibration might be helpful in considering this work in a broader archaeological context.

CHAPTER 3. LITHIC RAW MATERIAL RESOURCE BASE AND RESOURCE REGIONS

Get your facts first, then you can distort them as you please.
— Mark Twain

In order to understand the cultural use of lithic resources, we must first understand the natural resource base that supports it. This section examines that underlying resource base, and does so in three steps. The first is to review some ideas and terms that will be used throughout this and subsequent sections of this thesis. In particular this includes the ideas of raw material groups, regions, and zones. The second step is the presentation of a regional model of lithic raw material resources in Minnesota. In addition to describing new or revised regions, this includes more specific information on the distribution of individual raw materials within the regional contexts. The third step is to review the raw materials found at archaeological sites in the study region, including both locally available materials and the more commonly occurring nonlocal materials. This includes addressing what we can glean or infer about relative abundance, flaking quality and package size.[1]

GROUPS, REGIONS AND ZONES

First, it may be helpful to review some ideas and terms that will be used throughout this and subsequent sections of this thesis. In particular this includes the ideas of raw material groups, raw material resource regions, and raw material zones.

Raw Material Groups

The idea of raw material groups was first mentioned in Chapter 2 in connection with a hierarchy of raw material identification. The idea is potentially useful on two fronts, both in identification and in analysis.

The primary definition of raw material group is a set of raw materials that have related geologic origins and share related geographic distributions. A secondary definition, to be used with discretion, is a set of raw materials having a distant geologic origin and a common local

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[1] These terms are discussed in some detail in Chapter 4.

geographic distribution. Note that in both cases there is both a geologic and a geographic component to the definition. The definitions might be clarified by use of examples.

The Border Lakes Greenstone Group provides an example for the first definition – a set of raw materials that have related geologic origins and share related geographic distributions. This group includes three raw materials: Lake of the Woods Rhyolite, Lake of the Woods "Chert" (aka Siltstone, see below), and Knife Lake Siltstone. These materials all originate in the Early Precambrian greenstone belts that are exposed in parts of northwestern Ontario, including along the border lakes of the Ontario and Minnesota border (Ojakangas and Matsch 1982). In this setting, erosion of rhyolite provided the sediments for formation of siltstone. This lead to some overlap in macroscopic appearance between the two, in addition to the difficulty in distinguishing siltstone from different sources. The problem might be more tractable if the materials were only coming from primary geologic sources. Instead, however, they are widely distributed in glacial sediment and mingled to some degree. We might even wonder whether they share a more or less continuous distribution in glacial sediment, based on the locations of the greenstone belts and the known trajectories of glacial advances.

The definition of the Border Lakes Greenstone Group provides one way to deal with these such difficulties. The group allows us a way to make a slightly less specific raw material identification, but an identification that still provides specific information on physical characteristics and area of origin. Note that these two pieces of information are what generally make raw material identifications useful, at whatever level of specificity of the identification.

Also note, however, that the utility of a group identification is greatest at a distance from the source area and least within the source area. Think of a site in central Iowa, for example. Identification of Border Lakes Greenstone Group (BLG Group) materials at that site provides generally useful information: the materials in question originated from somewhere a few hundred kilometers to the north. More specific identification could help determine if the material originated from the north-northwest, north-northeast, or straight north. For a detailed study that might be valuable information, but for most practical purposes the identification of BLG Group tells you what you need to know.

For a site along the Ontario-Minnesota, in contrast, the picture looks a bit different since the site is within the BLG Group source area. For such a site, it might be important to more specifically identify the raw materials as a way of looking at questions like territories or connections between neighboring groups. Thus the idea of raw material groups is not a perfect tool, but maybe it is a tool that can help us focus our efforts productively when it comes to raw material identification and analysis.

The Western River Gravels Group (WRG Group) provides an example for the second definition – a set of raw materials having a distant geologic origin and a common local geographic distribution. This group is discussed in more detail below, and only briefly summarized here. This group includes a suite of many materials that originated as far west as the Rocky Mountains. Eastward-flowing, preglacial streams carried these materials to the east as components of stream-channel gravels, where materials from diverse sources were mingled. These gravels were later entrained by glacial ice, diluted, and spread broadly across the landscape. When these materials occur at sites, they could probably be specifically identified given sufficient time, effort, and access to western comparative collections. Such specific identifications, however, would not really add to the knowledge we gain by identifying them as part of the WRG Group – whatever their ultimate origin, the pebbles were gathered locally.

Raw Material Resource Regions, Subregions and Zones

The idea of raw material resource regions was introduced in a previous paper (Bakken 1997); it is more explicitly defined here (Table 3-1). In addition, the new concepts of subregions and zones are also introduced. The region is the broadest area, with subregions and zones each progressively smaller and more homogenous in terms of raw material resources.

Especially in glaciated landscapes, a raw material resource region is a geographic area distinguished by the co-occurrence of specific lithic raw materials, notwithstanding the wider distribution of one or more of these raw materials, or the presence of other raw materials in parts of the region. The region is distinguished in contrast to adjacent areas where a substantially different suites of raw materials occur.

Alternatively, and specifically in landscapes where the effects of glaciation are absent or minor, a raw material resource region is a geographic area distinguished by a common geologic history, so that the lithic raw materials in the region share a general mode of origin (sedimentary, igneous extrusive, etc.) and similar kind of availability in the landscape (exposure by erosion of carbonate rocks, etc.).

In terms of raw material resources, a raw material resource region is less homogenous than a subregion or zone.

Table 3-1. Definitions of raw material resource regions, subregions and zones.

Defined Examples	**Definition**
Region	
South Agassiz West Superior Pipestone Hollandale	Especially in glaciated landscapes, a raw material resource region is a geographic area distinguished by the co-occurrence of specific lithic raw materials, notwithstanding the wider distribution of one or more of these raw materials, or the presence of other raw materials in parts of the region. The region is distinguished in contrast to adjacent areas where a substantially different suites of raw materials occur. Alternatively, and specifically in landscapes where the effects of glaciation are absent or minor, a raw material resource region is a geographic area distinguished by a common geologic history, so that the lithic raw materials in the region share a general mode of origin (sedimentary, igneous extrusive, etc.) and similar kind of availability in the landscape (exposure by erosion of carbonate rocks, etc.). In terms of raw material resources, a raw material resource region is less homogenous than a subregion or zone.
Subregion	
South Agassiz: Tamarack South Agassiz: Upper Red South Agassiz: Shetek West Superior: Arrowhead West Superior: Quartz	A raw material resource subregion is a geographic area smaller than a region, and normally lying entirely within a region, and distinguished from other parts of the region by the presence or absence of certain lithic raw materials, or by clear differences in the flaking quality, package size, or abundance of one or more raw materials. In terms of raw material resources, a raw material resource subregion is more homogenous than a region but less homogenous than a zone.
Zone	
None formally defined	A raw material resource zone is a geographic area smaller than a subregion, and normally lying entirely with a subregion; it is distinguished from other parts of the subregion by having the same suite of lithic raw materials available throughout the zone, by having a consistency in the flaking quality of these lithic raw materials throughout the zone, and by having a consistency in the package size of these lithic raw materials throughout the zone. In terms of raw material resources, a raw material resource zone is more homogenous than a region or subregion.

A raw material resource subregion is a geographic area smaller than a region, normally lying entirely within a region, and distinguished from other parts of the region by the presence or absence of certain lithic raw materials, or by clear differences in the flaking quality, package size, or abundance of one or more raw materials.

In terms of raw material resources, a raw material resource subregion is more homogenous than a region but less homogenous than a zone.

A raw material resource zone is a geographic area smaller than a subregion, and normally lying entirely with a subregion; it is distinguished from other parts of the subregion by having the same suite of lithic raw materials available throughout the zone, by having a consistency in the flaking quality of these lithic raw materials throughout the zone, and by having a consistency in the package size of these lithic raw materials throughout the zone.

In terms of raw material resources, a raw material resource zone is more homogenous than a region or subregion.

This is a hierarchical system which progresses from general similarity in raw material resources to increasing homogeneity in such resources. Any level of the hierarchy provides a suitable context for comparative analysis of a lithic assemblage, and taken together the elements of this hierarchical system give us a way to examine lithic assemblages in broader or narrower contexts. For example, an assemblage might be generally compared to a large number of sites across a region, with the understanding that there are some differences in the underlying resource base for different assemblages. Thus the general pattern of similarities and differences might be informative, but some specific differences between the assemblages might arise from differences in the resource base rather than from human activity. In contrast the assemblage might be more specifically compared to other assemblages from the same resource zone, with the knowledge that the underlying resource base was essentially the same for all the associated assemblages, and that smaller variations between the assemblages might prove more significant.

This approach yields four resource regions for Minnesota (each continuing across state and provincial borders). Two of the regions are further divided into subregions. No zones are formally defined (although the concept is discussed at several points) because in most cases the information needed to define them is not available. The concept of zones, however, not only seems to be a logical extension of the definition of regions and subregions, but also would seem to be analytically useful. Therefore the idea is proposed, with the hope that definition of zones can be part of future research agendas.

Resource regions and subregions are further explained below, by way of extended discussion of the defined examples. Since no resource zones are explicitly defined, however, the idea is further discussed in a few additional paragraphs below, before the extended discussion of regions and subregions.

Raw Material Zones

For the most part, this thesis makes use of a regional approach to understanding raw material distribution. However, we could also think of raw materials distribution in a somewhat different manner, one that I will call "zonal" in order to distinguish it from the regional approach. The zonal approach has the advantage of being more explicit in making connections between raw material distributions, raw material characteristics, and geologic processes. This should be a good thing. Unfortunately, the zonal concept also has a disadvantage: we lack the information to see if it is really true or to put it into practical use. At present, it is of little use for actually analyzing the archaeological distributions of lithic raw materials.

What then is the use of even discussing a zonal concept of raw material distribution? As it happens, the concept is useful because it better integrates with the raw material use pattern that will be laid out at a later point in this thesis. It does this by more explicitly addressing certain characteristics of raw materials and raw material distributions that are integral to the use pattern model. More specifically these are general flaking quality, package size, and abundance, concepts that are defined and discussed in Chapter 4.

For now we might summarize the matter this way: the regional concept is practical for "everyday" use, while the zonal concept is useful for taking a more abstract view of raw material use.

Where the regional concept focuses more on where various raw materials can be found, the zonal concept focuses more on how they got there. An important element of the zonal approach is what geologists call a "vector of transport." This might be best explained using a couple of examples. The first is provided by the Western River Gravels Group. In this case we begin with Cenozoic rivers that begin far to the west and flow to the east. Over the course of their length, they entrain clasts of various kinds of toolstone from many western sources. These toolstone clasts become part of the river gravels. The toolstone clasts are gradually moved eastward, eventually far beyond their area of origin. This is the first vector of transport. Later, in the Pleistocene, some of these river gravels are entrained by glacial ice flowing to the south. The toolstone clasts from the gravels are thus spread in another direction by another mechanism – a second vector of transport.

Tongue River Silica (TRS) provides a second example, albeit one that is conjectural. In this scenario, Tongue River Silica originates northwest of the immediate Minnesota study area, perhaps in the vicinity of the Turtle Mountains of North Dakota and Manitoba. A relatively early, poorly known glacial advance entrains quantities of TRS and spreads it to the southeast as far as central Iowa. This is the first vector of transport. At a later time, Rainy lobe ice advancing from the northeast incorporates some of the earlier till, including the clasts of TRS, and spreads it to the southwest. This is the second vector of transport. Still later the Des Moines lobe advances from the north, incorporates TRS-enriched till from the Rainy lobe, and spreads it to various points southward. This is the third vector of transport.

To really see the usefulness of the zonal concept, however, we need to also consider what kinds of transformations toolstone clasts might have undergone in each vector of transport. In the first example, consider the clasts of the Western River Gravels Group. Riverine transport – the first vector of transport – would have mingled raw materials of diverse origins, and would have concentrated raw materials in relatively focal sources by winnowing away softer clasts. In other words, the erosive action of the river would have removed finer sediments and left concentrations of toolstone clasts along the immediate course of the river. In addition, the pieces of toolstone would have bit-by-bit become smaller and rounder as they were tumbled along the streambed. Glacial transport – the second vector of transport – would likely have mingled the river-gravel clasts with still more kinds of toolstone from still more sources. It probably also contributed to further reducing the size of the river gravel clasts, but possibly produced somewhat more angular fragments as rounded pebbles were split apart. And quite unlike the case with the rivers, the glacial vector of transport would have spread the river gravel materials more thinly across the landscape instead of concentrating them in a relatively restricted source area.

Similar effects can be seen with the example of Tongue River Silica. Some evidence suggests that the first vector of glacial transport – from the northwest – spread large amounts of TRS, and at least some of it in relatively large pieces. The result was a relatively (emphasis on relatively) dense distribution of larger pieces of TRS across the landscape. The second vector of glacial transport – the Rainy lobe from the northeast – resulted in both a more dispersed distribution of TRS in parts of the landscape, and a reduction in the average size of TRS clasts (comminution). The third vector of glacial transport – the Des Moines lobe from the north – results in an even more diffuse distribution of TRS in parts of the landscape (or zones), and even smaller pieces.

Just thinking about vectors of transport might be useful enough. It might also, however, prove more useful to carry this a step farther and think about raw material zones. Again, this might be best explained by using a couple of examples. For the sake of continuity, we can continue to make use of the examples used above. In the case of TRS, we can define one zone based on the first vector of transport. This zone includes areas where older, poorly known tills are exposed in a small part of southwestern Minnesota, a somewhat large part of eastern South Dakota, and a good part of northwestern Iowa. In this zone, TRS is common and is available in larger pieces. It is mingled with other raw materials, each of which could be also discussed in terms of their relative abundance in the landscape and relative size. To do this, we could trace the origin and distribution histories of each raw material in much the same way that we did for TRS in preceding paragraphs. The zone has a certain coherence, even a certain homogeneity, both in geologic terms and in terms of raw material availability.[2]

Another zone could be defined in relation to areas of central Minnesota where the uppermost glacial sediments are associated with the Wadena lobe. This represents the second vector of transport for TRS. In this zone, TRS is still common but is conjecturally less abundant than in the zone discussed immediately above. In addition, we should expect that the pieces of TRS are smaller on average. Further, they are mingled with different, or at least additional, kinds of raw materials – originating from the northeast rather than the northwest. (Note that in this case there is a poor coincidence of zone and region. As a practical matter, surficial exposures of the Wadena lobe are split between the South Agassiz Region and Quartz Subregion.)

The third vector of TRS transport provides an opportunity for defining yet another zone, this time one that helps distinguish subregions within a resource region. It appears that the original Des Moines lobe sediment contained no TRS. As the Des Moines lobe overrode the Wadena lobe, however, it began to incorporate Wadena lobe till – including clasts of TRS. Thus south of a line the Des Moines lobe till includes a relatively thin scattering of smaller pieces of TRS; north of this line, TRS is absent. The line in this case marks the

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2. The reader may have noted that, based on this description, the zone is coincident with the Pipestone Resource Region. This is probably not actually the case, however, as till deposits and exposures in the Pipestone Resource Region are likely more diverse and complex than this example suggests.

approximately defined border between the Tamarack and Upper Red subregions of the South Agassiz Resource Region.

We can contrast this zonal way of thinking about TRS with how TRS is handled in the regional model, as a way of highlighting the differences between the two approaches. The regional model specifies that the regions do not account for the distribution of TRS, and provides some information about how the distribution of TRS relates to the regions and subregions. In many respects this is adequate for the purposes of the model and its use as an analytical tool. In contrast, note that the discussion of raw material zones provides much more specific ideas about the distribution of TRS – and its characteristics – although at this time it does not provide a useable tool for analyzing TRS distribution at archaeological sites. (Zonal distributions are, unfortunately, further complicated by the exposure of older and more deeply buried TRS-bearing tills in incised areas like the Minnesota River Valley.)

If the zonal concept can be augmented with more and more specific data, both geologic and raw material survey, it conceivably could displace the regional model as an analytical tool. At present, however, it remains out of reach, and we may have to strive to make due with the more workaday regional resource model. Meanwhile, the zonal concept still is useful in augmenting the regional model, as should become more clear in discussions revolving around the regional raw material model.

LITHIC RAW MATERIAL RESOURCE REGIONS

The model presented here is a revision of a previous model (Bakken 1997). The earlier version discussed raw material availability in terms of three regions based on the geological history of the state and especially Quaternary glacial history. The three regions corresponded roughly to areas dominated by glacial till originating from the northwest, from the northeast, and by bedrock-related raw material sources.

The model proved to have some analytical utility. Use of the model has, however, made some shortcomings apparent. Researchers have noted, for example, that because the model is very generalized, it must be "localized" to be useful at a given site (e.g., Hohman-Caine and Goltz 1997:10). That is, interpretations must consider raw material availability within a smaller area around the site rather than just the very broad distributions considered by the model. The proposed revisions do not eliminate this concern; hopefully, however, they lessen it by providing more accurate and more tightly focused definitions. Questions have also been raised about the location of the proposed raw material region boundaries (e.g., Gonsior et al. 1996:sec 6, p. 8). The proposed revisions will hopefully directly address these questions also.

At various times I have attempted minor revisions to the model, usually in connection with a lithic analysis prepared for a particular cultural resource management project. The main outcome was not necessarily any particular improvement to the model, but instead an unfortunate inconsistency in the naming of the regions. The original southern region was sometimes referred to as the southeastern region. The original eastern region was sometimes referred to as the northeastern region, except for parts of it that may have been called the central or quartz region. Happily the western region remained the western region, the Pipestone region was never brought up, and I hope that I may be excused for the rest of the regional confusion.

The revised model builds on the original model, but proposes four regions instead of three and also defines a set of subregions. Because the regions were previously named only to reflect their relative location within Minnesota (western, eastern, southern), the regions are renamed to reflect that they continue beyond the borders of the state. The revised model also adjusts the borders between regions, in some cases substantially. The association between regions and raw materials is also re-examined.

There is another important distinction between the previous and revised models. The earlier version of the model was based mostly on geological history, especially the distribution of different glacial tills. The revised model begins with this foundation, but some refinements are also based on archaeological distributions of raw materials. This creates an apparent conflict. Geological data represent the effects of natural processes, while archaeological data represents the effects of human activities. The geological data should support a model of raw material availability, while the archaeological data should support a model of raw material use.

I would argue that this dichotomy is not as clear as it first seems, based on three lines of reasoning. First, most of the archaeological data comes from flaking debris that remains at near to the source area, and thus most of the archaeological data reflect geological distribution of raw material. Second, there is good correlation between the geological and archaeological data; the former is used to establish general boundaries, while the latter is used only to refine boundaries. Third, it is relatively easy in most cases to identify exotic and nonlocal raw materials in the archaeological sample, and to exclude them when considering geological distributions.

First, most of the data used in this study reflect the distribution of flaking debris. I propose that the bulk of this flaking debris remains at or near the raw material source area, and thus closely reflects the geological distribution of flakeable raw materials in the state. This supposes that traditional flintknappers would first test cobbles for general quality, and then carry out initial reduction of raw material stock at the source area (or very near, in terms of statewide distributions) (cf. Binford and O'Connell 1984:421; Callahan 1979:90). These steps help ensure selection of workable material, and reduce both bulk and weight of workable material that might be transported to be finished at another location. Although some of the material is transported to a distant location, and thus some of the flaking debris is deposited away from the source, the bulk of the flaking debris remains at the raw material source. This does not preclude production of completed tools at a raw material source, in which case even more of the total raw material would remain at the source. For another perspective, consider the spectrum of curated tool to expedient tool production. The scenario outline above better resembles curation. Expedient tool production would leave even more raw material, both flaking debris and exhausted expedient tools, at the raw material source.

Note, however, that the effects may be somewhat different in glaciated and unglaciated areas. In the glaciated areas, raw material sources are diffuse and the same materials are found over wide areas. In such situations the effects of short-distance transportation of raw materials are negligible; Swan River Chert can be found from Alberta to Iowa, and the transportation of a few pieces for a few miles has little or no net effect on distinguishing geological and archaeological distributions of the material. In unglaciated areas raw material sources tend to be focal. In the case of Grand Meadow Chert, for example, the transportation of a few pieces away from the Grand Meadows quarries may actually be apparent in maps of archaeological distribution. These distributions will, however, still center on the source area. It might be legitimate to propose that the evidence for transport of raw materials at archaeological sites *blurs* the picture of geological distribution, but does not *obscure* it. In effect, archaeological distribution of raw materials gives us a rendering of geological distribution that is simply slightly out of focus.

Second, there is good correlation between the geological and archaeological data. The geological data are used to establish general boundaries. The archaeological data suggest where regional boundaries may be refined, but they do not suggest changes in the underlying, geologically-based resource regions. An example may prove useful. One method that has contributed substantially to untangling the glacial history of the state is the study of indicator stones. The clasts or grains from a sample of glacial sediment are sorted by lithology; that is, they are sorted by rock type, with the various rock types indicating different source areas. Red volcanics are associated with the Lake Superior region (northeast), for example, while shale is associated with the Red River lowlands (northwest). The quantification of indicator stones help determine not only the general origin of a glacial till, and also the degree to which different tills have become mixed. Thorleifson et al. (2007) report on a recent study of 250 till samples from around (or just beyond the borders of) the state (Thorleifson et al. 2007:Fig. 2). Note, for example, the correspondence between the occurrence of higher percentage of carbonate (Thorleifson et al. 2007:Appendix 2, Carbonate) and the South Agassiz Resource Region (Figure 2-3; also see Appendix 1-1).

Thinking along these lines, the present study might even be considered a sort of indicator-stone survey. The preliminary sampling, however, was done by a diverse (and highly motivated) human population over the course of several millennia, with a secondary subsample retrieved by archaeologists over the course of the last few decades. The number of sampling locations (as represented here) totals over 1200. Rather than sorting an entire gravel fraction by general lithology, we are sorting a selected part of the fraction (highly siliceous rocks) by very particular, well-studied types. In this view, the archaeological data could in fact provide useful information for the study of glacial history – that is, provided that the premise is correct that the bulk of flaking debris remains at or near the raw material source.

It might be further noted that the mapping of surface geology on a statewide scale may not be precise and may in some cases even be inaccurate. Detailed maps of smaller regions are likely to be dependable, because they are based on a denser set of detailed observations. A statewide map, in contrast, may not be based on detailed observations for all areas that are mapped. Instead, it may rely on interpolation between better-mapped areas, and on remote interpretation of data sets such as aerial photos and topographic maps. Finally, a larger-scale map may necessarily gloss over disagreements about the assignment, correlation or even identification of particular till units, and so miss useful detail. Thus in cases where a generalized map of surface geology masks some imprecision or inaccuracy, the archaeological distribution of raw materials provides a second line of evidence for defining resource regions.

Third, it is relatively easy in most cases to identify exotic and nonlocal raw materials in the archaeological sample so that the presence of these materials is not taken as evidence of local availability. In the case of exotic materials, with one exception, the source regions are well defined, lie outside the state, and there is no evidence that the materials occur in the state except as artifacts on archaeological sites. Knife River Flint, the exception, does occur in the state. The natural distribution of this material, however, has been studied separately. The evidence indicates that it is uncommon in Minnesota, and occurs as small pieces of inferior quality (Bakken 1997; Gregg 1987a; see also Anderson 1980:200; Billeck et al. 1986:56; Morrow 1994:128). Studies by Gregg (1987a) and my own experience indicate that in site assemblages it is also often possible to distinguish primary source-region KRF from glacially-distributed KRF. It seems clear that the bulk of the KRF found at archaeological sites in the state comes from sources outside the state, and that a detailed study could identify and study the distribution of KRF in glacial sediment within Minnesota. Many other nonlocal materials also come from source regions that are well defined and lie outside the state. Examples include Fusilinid Group cherts, Moline Chert or Maynes Creek Chert. The reasoning applied to exotics also applies to such materials.

In the case of materials moving between adjacent regions within the state, the situation might be less clear. Note, however, that we have a reasonably clear idea of where various raw materials occur naturally in the state, so it is possible to make informed judgements for a given site about which materials represent local procurement and which represent human transport. It is also helpful to keep these points in mind: the relative amount of material transported by humans should be small, there should be little incentive to transport materials of marginal quality, and materials do not move upstream relative to glacial ice flow.

Finally it should be acknowledged that the revised model is in some respects a hybrid. The model can and likely should be tested against a larger set of nonarchaeological data.

Revised Raw Material Resource Regions

Minnesota includes parts of four raw material resource regions: South Agassiz, West Superior, Pipestone and Hollandale (Figure 2-3). Each contains a different set of raw materials from different combinations of raw material sources. The boundaries between these regions are not clear, and no attempt need be made to define them clearly. The four-region concept is a radical simplification of a complex situation, but it is the complexity of the situation which makes such a simplification useful. The region concept is an analytical device, to be used with appropriate caution.

This four-region model is based on Minnesota's geological history. The state contains a variety of rocks and sediments which range from recent to over 3 billion years in age. The surface throughout most of the state has been shaped by the geologically recent actions of glaciers, which tore rocks from their original contexts, mixed them together and spread them over the state. Later ice advances might incorporate older glacial tills, mix them with the new till and carry the mixture in an entirely new direction. In addition, in some areas the ice exposed bedrock by scraping it clean of soil and other sediment. Locally the landscape has also been altered by subsequent erosion and deposition, process that have redistributed raw materials, exposed once-buried raw material sources, or buried once-accessible sources.

Of the several major episodes of glaciation in North America, the most recent had the most substantial effect on the present surface geology of Minnesota. This episode, known as the Wisconsin glaciation, ended here no more than 10,000 years ago. During the Late Wisconsin glaciation, several large ice masses advanced across the state. They originated primarily from two directions: northwest and north to northeast. The ice which came from the north to northwest (Red River and Des Moines lobe) crossed Paleozoic sedimentary rock, mostly limestone and related carbonates. These glaciers deposited grey and brown drift across northwestern, western, central and parts of southern Minnesota. The ice which came from the north to northeast (Rainy and Superior lobes) crossed older volcanic, metamorphic and sedimentary rocks. The Superior lobe left reddish sediment in northeastern and east-central Minnesota, while the Rainy lobe left variably colored sediment across adjacent parts of the state (see Clayton and Moran 1982; Fenton et al. 1983; Hobbs and Goebel 1982; Sims and Morey 1972:16-17; Wright 1972:520-546).

Note however that older tills are also exposed in parts of the state. Areas with old till include most of Pipestone and Rock counties in southwestern Minnesota, as well as most of Mower and Dodge and parts of Dakota, Rice, Goodhue, Olmsted and Fillmore counties in southeastern Minnesota. This older till lies in a band around the farthest extent of the Des Moines lobe. In addition to surface exposures, older tills are exposed by deeper erosion in some places (e.g., along the Minnesota River Valley).

In addition some parts of southeastern Minnesota were not affected by recent glaciations; these areas contains bedrock exposures and lag deposits of raw materials. This includes most of Goodhue, Wabasha, Olmsted, Winona, Fillmore and Houston counties.

Although this revision of the model continues to rely heavily on generalized surface geology, archaeological data is also considered in refining region boundaries and defining the resources within each region (as discussed above).

Based on these sets of evidence, the boundaries of the regions have been redrawn (Figure 2-3, Table 3-2). In the northern two-thirds of the state, the old and new boundaries are relatively similar. In the southern third of the state, however, the old and new boundaries

Table 3-2. List of counties associated with each lithic raw material resource region and subregion.

	Counties completely within the subregion				**Counties partly within the subregion**	
South Agassiz Resource Region						
Tamarack Subregion	Beltrami	BL	Pennington	PE	Clearwater	BL
	Kittson	KT	Polk	PL	Koochiching	CE
	Lake of the Woods	LW	Red Lake	RL		KC
	Marshall	MA	Roseau	RO		
Upper Red Subregion	Becker	BK	Norman	NR	Clearwater	CE
	Big Stone	BS	Otter Tail	OT		
	Clay	CY	Pope	PO		
	Douglas	DL	Stevens	SE		
	Grant	GR	Traverse	TR		
	Mahnomen	MH	Wilkin	WL		
Shetek Subregion	Brown	BW	Meeker	ME	Carver	CR
	Cottonwood	CO	Martin	MR	Hennepin	HE
	Chippewa	CP	Murray	MU	Nicollet	NL
	Jackson	JK	Nobles	NO	Sibley	SB
	Kandiyohi	KH	Renville	RN	Stearns	SN
	Lincoln	LN	Redwood	RW	Wright	WR
	Lac qui Parle	LP	Swift	SW		
	Lyon	LY	Watonwan	WW		
	McLeod	MC	Yellow Medicine	YM		
West Superior Resource Region						
Arrowhead Subregion	Cook	CK	Lake	LA	Koochiching	KC
	Itasca	IC	St. Louis	SL		
Quartz Subregion	Aitkin	AK	Kanabec	KB	Anoka	AN
	Benton	BN	Mille Lacs	ML	Hennepin	HE
	Carlton	CL	Morrison	MO	Stearns	SN
	Cass	CA	Pine	PN	Wright	WR
	Crow Wing	CW	Sherburne	SH		
	Hubbard	HB	Todd	TO		
	Isanti	IA	Wadena	WD		
Pipestone Resource Region						
	Rock	RK			Pipestone	PP
Hollandale Resource Region						
	Blue Earth	BE	Mower	MW	Anoka	AN
	Chisago	CH	Olmsted	OL	Carver	CR
	Dakota	DK	Ramsey	RA	Hennepin	HE
	Dodge	DO	Rice	RC	Nicollet	NL
	Faribault	FA	Scott	SC	Sibley	SB
	Fillmore	FL	Steele	SE		
	Freeborn	FE	Wabasha	WB		
	Goodhue	GD	Waseca	WE		
	Houston	HU	Winona	WN		
	LeSueur	LE	Washington	WA		

bear little resemblance to each other. Note that, also as before, the boundaries between regions are intended to be approximations. There is emphatically no line in the sand – or in this case no line in the glacial till.

One additional region is also proposed. This region was previously overlooked because it includes only a small corner of southwestern Minnesota. The majority of this region lies in northwest Iowa, and smaller parts in eastern South Dakota.

In addition, a number of subregions are proposed. These are generally based on variations in the availability of specific raw materials within a region. One subregion definition, however, is based on slightly different considerations, further discussed below.

Note that the definition of a region – or a subregion – is not meant to imply uniform availability of raw materials across that region. Rather it is meant to indicate that certain raw materials are widespread, and were widely utilized, throughout the region or subregion. A site-specific analysis can always be improved by reference to an inventory of raw materials available in the immediate vicinity of site, within a certain radius of a site, or only at some greater distance from a site (whether those materials are defined as nonlocal or exotic).

Within a region, all lithic raw materials are not of equal importance. Some materials are common, others rare. Some materials were commonly used in prehistory, others only infrequently so. In the following discussion, "primary materials" are those which are commonly available as raw materials and also commonly found at archaeological sites. "Secondary materials" are less abundant as raw materials, and also less frequently found as artifacts. Finally, "other materials" are relatively uncommon either as raw materials or at sites (Table 3-3).

In most cases, primary raw materials are easily determined. There are usually one or more materials that are much more abundant than other materials in the archaeological record. It is more difficult, however, to find a consistent separation between secondary and minor raw materials. As an approximate rule of thumb, secondary raw materials constitute 5 percent or more of the raw material sample in a region or subregion (or constituting 5 percent or more of the raw material samples in at least two use patterns). Table 3-3 provides what should be a reasonable evaluation of relative raw material importance, although the designations should not be considered absolute.

The regions have also been renamed to reflect a broader geographic perspective. The previous names – western, southern, eastern – refer to their location within the state of Minnesota. The regions continue beyond the limits of the state, however, and these directional references make little sense from the perspective of a neighboring state or

Table 3-3. Estimated primary, secondary and minor lithic raw material status by region and subregion.

	Primary Raw Materials	**Secondary Raw Materials**	**Minor Raw Materials**	**Main Exotic Raw Materials**
South Agassiz Resource Region				
Tamarack Subregion	Swan River Chert Red River Chert	Border Lakes Greenstone Group	quartz Tongue River Silica Western River Gravels Group ?	Knife River Flint
Upper Red Subregion	Swan River Chert	Red River Chert Tongue River Silica Quartz	Border Lakes Greenstone Group Western River Gravels Group	Knife River Flint
Shetek Subregion	Swan River Chert	Tongue River Silica Red River Chert Quartz	Border Lakes Greenstone Group Western River Gravels Group	Knife River Flint Burlington
West Superior Resource Region				
Arrowhead Subregion	Gunflint Silica Knife Lake Siltstone	quartz Hudson Bay Lowland Chert Jasper Taconite	Border Lakes Greenstone Group	Knife River Flint
Quartz Subregion	Knife Lake Siltstone Tongue River Silica Quartz *(Fat Rock and other)*	Swan River Chert	Lake of the Woods Rhyolite Biwabik Silica Gunflint Silica Jasper Taconite Kakabeka Chert Hudson Bay Lowland Chert Lake Superior Agate	Knife River Flint Hixton Group Burlington
Pipestone Resource Region				
	Tongue River Silica Gulseth Silica ?	Sioux Quartzite Swan River Chert ? Red River Chert ?	quartz	Knife River Flint
Hollandale Resource Region				
	Cedar Valley Chert Galena Chert Grand Meadow Chert Prairie du Chert	Shell Rock Chert ?	quartz Tongue River Silica Swan River Chert Red River Chert	Hixton Group

province. The western resource region, for example, also exists in the eastern Dakotas. While the new names may contain directional elements, these elements reference a larger geography.

The South Agassiz Region largely corresponds with the old western region. The name was chosen to reflect the fact that much of this region is contained with the southern basin of Glacial Lake Agassiz. The West Superior Region corresponds with the old eastern region. The name was chosen to reflect its location relative to a major and persistent landscape feature, Lake Superior. The Hollandale Region partly corresponds with the old southern region. The name was chosen to reflect its association with the Hollandale Embayment, an arm of an ancient sea where the existing sedimentary rocks (including flakeable rocks) were deposited. The Pipestone Region is new.

The data in Tables 3-4, 3-5 and 3-6 illustrate the degree of variability in raw material occurrence with and between the regions and subregions. Each of the numbers is a percentage. The middle number in each cell (boldfaced) is the average percentage for a particular area. The top and bottom figures (italicized) are the highest and lowest percentage for a county in the particular area. Most of the rows present data for a particular raw material or raw material group. In the case of headers like "South Agassiz Materials" (first row), the data includes the materials immediately following (here Swan River Chert, Red River Chert and silicified wood) and may include associated materials not specifically named when those other materials occur in very small amounts.

South Agassiz Resource Region

The South Agassiz Resource Region covers about the western third of the state, with eastward extensions along the Ontario border and near the Twin Cities, and with the exclusion of a small area in the southwestern-most corner of the state (Figure 2-3). This includes all or part of 46 counties (Table 3-2). The region continues into southern Manitoba, eastern North Dakota and South Dakota, and north-central to central Iowa. The limits of the resource region are not defined, however, outside of Minnesota. The region is dominated by glacial and lake sediments. Scattered bedrock outcrops are found along the Ontario border and in the southern part of the region. In the north, large areas in the Agassiz lakebed are essentially stone free, and stone is also inaccessible in large areas of peatland. Conversely, stone is concentrated in multiple series of Agassiz beach ridges. Swan River Chert is the most important raw material, and Knife River Flint the most important exotic (Table 3-3).

Table 3-4. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for state of Minnesota as a whole and for resource regions; all figures are for county-wide aggregations.

	Minn Statewide	*South Agassiz*	*West Superior*	*Pipestone*	*Hollandale*
South Agassiz Materials	*82.0* **18.3** *0.0*	*82.0* **61.8** *32.3*	*23.8* **4.4** *0.0*	*21.6* **19.7** *14.6*	*28.7* **2.1** *0.0*
Red River Chert	*43.1* **4.1** *0.0*	*43.1* **14.9** *0.9*	*4.2* **0.9** *0.0*	*6.8* **5.3** *1.2*	*6.3* **0.4** *0.0*
Silicified Wood	*1.3* **0.0** *0.0*	*1.1* **0.1** *0.0*	*0.2* **0.0** *0.0*	*0.0* **0.0** *0.0*	*0.2* **0.0** *0.0*
Swan River Chert	*78.1* **14.2** *0.0*	*78.1* **46.8** *20.3*	*20.1* **3.5** *0.0*	*14.9* **14.3** *13.4*	*23.7* **1.8** 0.0
West Superior Materials	*76.7* **6.7** *0.0*	*6.8* **1.1** *0.0*	*76.7* **9.2** *0.0*	*0.0* **0.0** *0.0*	*4.4* **0.3** *0.0*
Animikie Group (*not specified*)	*18.2* **0.6** *0.0*	*1.2* **0.0** *0.0*	*18.2* **1.1** *0.0*	*0.0* **0.0** *0.0*	*0.8* **0.0** *0.0*
Gunflint Silica	*40.9* **1.7** *0.0*	*5.5* **0.5** *0.0*	*40.9* **2.3** *0.0*	*0.0* **0.0** *0.0*	*1.0* **0.1** *0.0*
Hudson Bay Lowland Chert	*21.6* **1.8** *0.0*	*6.8* **0.4** *0.0*	*12.9* **1.6** *0.0*	*0.0* **0.0** *0.0*	*2.5* **0.1** *0.0*
Jasper Taconite	*9.0* **2.0** *0.0*	*1.0* **0.1** *0.0*	*9.0* **3.2** *0.0*	*0.0* **0.0** *0.0*	*0.6* **0.0** *0.0*
Kakabeka Chert	*4.4* **0.2** *0.0*	*0.4* **0.0** *0.0*	*4.4* **0.4** *0.0*	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*
Lake Superior Agate	*3.0* **0.3** *0.0*	*1.1* **0.1** *0.0*	*3.0* **0.6** *0.0*	*0.0* **0.0** *0.0*	*0.2* **0.0** *0.0*
Hollandale Materials	*96.4* **16.5** *0.0*	*21.4* **2.1** *0.0*	*24.3* **2.1** *0.0*	*22.0* **8.2** *3.2*	*96.4* **86.5** *44.4*
Cedar Valley Chert	*41.2* **2.5** *0.0*	*1.8* **0.2** *0.0*	*5.1* **0.3** *0.0*	*0.0* **0.0** *0.0*	*41.2* **13.7** *0.0*

Table 3-4. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for state of Minnesota as a whole and for resource regions; all figures are for county-wide aggregations.

	Minn Statewide	*South Agassiz*	*West Superior*	*Pipestone*	*Hollandale*
Galena Chert	*48.0* **2.7** *0.0*	*2.0* **0.2** *0.0*	*0.7* **0.0** *0.0*	*1.2* **0.7** *0.5*	*48.0* **16.3** *0.0*
Grand Meadow Chert	*28.6* **1.3** *0.0*	*9.4* **0.4** *0.0*	*0.4* **0.1** *0.0*	*1.2* **0.7** *0.5*	*28.6* **7.2** *0.0*
Prairie du Chien Chert	*91.0* **9.2** *0.0*	*14.7* **1.3** *0.0*	*19.1* **1.7** *0.0*	*19.5* **6.9** *2.3*	*91.0* **44.8** *4.4*
Shell Rock Chert	*51.1* **0.7** *0.0*	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*	*51.1* **4.3** *0.0*
Pipestone Materials	*31.1* **0.0** *0.0*	*1.1* **0.0** *0.0*	*0.0* **0.0** *0.0*	*31.1* **33.6** *0.0*	*0.0* **0.0** *0.0*
Gulseth Silica	*31.1* **0.0** *0.0*	*1.1* **0.0** *0.0*	*0.0* **0.0** *0.0*	*31.1* **22.7** *0.0*	*0.0* **0.0** *0.0*
Tongue River Silica	*39.7* **6.7** *0.0*	*37.0* **5.2** *0.0*	*39.7* **9.7** *0.0*	*32.9* **22.0** *18.0*	*2.8* **0.4** *0.0*
Quartz	*93.3* **29.7** *0.0*	*19.8* **5.6** *0.3*	*93.3* **50.1** *1.3*	*1.8* **1.6** *1.2*	*12.4* **1.7** *0.0*
Border Lake Greenstone Group	*65.9* **10.5** *0.0*	*18.6* **3.3** *0.0*	*65.9* **16.1** *0.0*	*0.0* **0.0** *0.0*	*4.0* **0.2** *0.0*
Knife Lake Siltstone	*64.4* **0.4** *0.0*	*6.6* **0.7** *0.0*	*64.4* **14.7** *0.0*	*0.0* **0.0** *0.0*	*3.0* **0.1** *0.0*
Lake of the Woods Siltstone	*2.8* **0.0** *0.0*	*2.8* **0.2** *0.0*	*0.2* **0.0** *0.0*	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*
Lake of the Woods Rhyolite	*26.6* **2.1** *0.0*	*14.7* **2.4** *0.0*	*26.2* **1.4** *0.0*	*0.0* **0.0** *0.0*	*1.2* **0.1** *0.0*
Western River Gravels Group	*0.8* **0.1** *0.0*	*0.5* **0.1** *0.0*	*0.3* **0.0** *0.0*	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*

Table 3-4. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for state of Minnesota as a whole and for resource regions; all figures are for county-wide aggregations.

	Minn Statewide	*South Agassiz*	*West Superior*	*Pipestone*	*Hollandale*
Sioux Quartzite Group	*14.9* **0.0** *0.0*	*0.3* **0.0** *0.0*	*3.7* **0.0** *0.0*	*14.9* **10.9** *0.0*	*0.4* **0.0** *0.0*
Sioux Quartzite	*14.9* **0.0** *0.0*	*0.3* **0.0** *0.0*	*3.7* **0.0** *0.0*	*14.9* **10.9** *0.0*	*0.4* **0.0** *0.0*
Other (*cf. chopping tool materials*)	*16.5* **1.2** *0.0*	*6.3* **1.5** *0.0*	*16.5* **1.3** *0.0*	*0.0* **0.0** *0.0*	*3.8* **0.5** *0.0*
Generic Identifications	*23.9* **6.4** *0.9*	*23.9* **9.7** *3.0*	*13.3* **5.4** *1.3*	*23.2* **9.5** *4.5*	*23.4* **5.2** *0.9*
Exotic Materials	*21.9* **3.4** *0.0*	*21.9* **7.6** *0.3*	*19.0* **1.8** *0.0*	*61.* **3.3** *2.3*	*14.1* **3.1** *0.2*
Burlington Chert	*11.1* **0.2** *0.0*	*2.0* **0.2** *0.0*	*0.8* **0.1** *0.0*	*0.0* **0.0** *0.0*	*7.2* **0.6** *0.0*
Hixton Quartzite	*12.6* **0.6** *0.0*	*1.7* **0.1** *0.0*	*3.3* **0.4** *0.0*	*0.0* **0.0** *0.0*	*12.6* **2.3** *0.0*
Knife River Flint	*21.6* **2.5** *0.0*	*21.6* **7.2** *0.3*	*19.0* **1.3** *0.0*	*6.1* **3.3** *2.3*	*1.6* **0.3** *0.0*
Obsidian	*0.5* **0.0** *0.0*	*0.5* **0.0** *0.0*	*0.3* **0.0** *0.0*	*0.0* **0.0** 0.0	*0.0* **0.0** *0.0*
Other Nonlocal Materials	*9.7* **0.5** *0.0*	*9.7* **1.9** *0.0*	*0.0* **0.0** *0.0*	*2.7* **2.0** *0.0*	*2.1* **0.1** *0.0*
Fusilinid Group					
Maynes Creek Chert					

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one subregion; other materials may occur but are not specifically listed. Counties spanning more than one resource region are included in statewide figures, but not regional figures.

This region is dominated by Des Moines lobe till and glacial lake sediments, but also includes some areas of Wadena lobe till. The Des Moines lobe represents the last ice advance through this area at the end of the Wisconsin glaciation. It advanced from the Winnipeg Lowland in the north, carrying a rich load of carbonates and associated cherts, and apparently incorporating other materials from older, underlying tills as it advanced. The Wadena lobe is part of the Rainy lobe advance that incorporated sediment from the underlying Browerville till, a clay- and carbonate-rich till originating from the northwest. This incorporation was progressive: the amount of incorporated Browerville till increases as the ice advances, to the point that the resulting mixed till looks more like Browerville till than Rainy lobe till (Goldstein 1985).[3]

Scattered bedrock outcrops are found along the Ontario border and in the southern part of the region. It is not clear that the northern bedrock outcrops provide any toolstone. The same could be said of many bedrock outcrops along or near the Minnesota River. Outcrops of the basal conglomerate of the Sioux Quartzite, however, were a minor raw material source.

The northern end of the region is dominated by the lakebed of Glacial Lake Agassiz. Large parts of the lakebed are generally free of stone, especially in the areas closer to the Red River. The lake stabilized at various levels during the course of its existence, building a series of beaches that often contain stone. These now exists as a series of sand and gravel ridges that stretch for sometimes hundreds of miles, and that provided a potential toolstone source for traditional flintknappers.

The northern part of the region also contain large peatlands where stone would be largely inaccessible. Note, however, that these peatlands probably first developed 3,000 to 4,000 years ago (Wright et al. 1992), so raw material availability could have been significantly different before that time.

Swan River Chert (SRC; Appendix 1-3) is a primary raw material through the region, although it is most important in the north and somewhat less so to the south (Tables 3-3, 3-5). This may reflect a greater abundance of SRC in the north, the availability of a wider range of raw materials to the south, or both. Red River Chert (RRC; Appendix 1-2) is also a primary material to the north, but only a secondary material to the south. This probably reflects greater abundance and larger clast size to the north, nearer the primary geologic source.

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3. Note, however, that this interpretation of the Wadena lobe has been revisited and is being reconsidered.

The Border Lakes Greenstone Group materials (Appendix 1-23 to 1-26) constitute secondary raw materials to the north, but diminish in importance to minor materials in the south. Tongue River Silica (Appendix 1-21) constitutes a secondary raw material to the south, while it is absent as a natural resource from the northern reaches of the region. Quartz (Appendix 1-22) is similarly a secondary raw material to the south, while it is only a minor raw material to the north. Western River Gravel Group materials (Appendix 1-27) are a minor resource, probably throughout the region.

Knife River Flint (Appendix 1-32) is clearly the most important exotic raw material in the South Agassiz Region. At a few sites, it is even the most common raw material. Burlington Chert (Appendix 1-30) is also a noteworthy exotic in the southern reaches of the region. Obsidian (Appendix 1-33) occurs in small amounts at some sites.

Tamarack Subregion

The Tamarack Subregion includes all or part of 10 counties in northwestern Minnesota (Figure 2-3, Table 3-2). The subregion continues into eastern North Dakota and southern Manitoba, but the limits of the subregion are not defined outside of Minnesota. In northwestern Ontario, the beginnings of bedrock outcrops suggests that the Tamarack Subregion probably does not continue far into the province, although this claim should be investigated more closely. The subregion is dominated by glacial sediment, although near the Red River large areas in the Agassiz lakebed are essentially stone free, and to the east stone is also inaccessible in large areas of peatland. Scattered bedrock outcrops are found along the Ontario border. Swan River Chert is the most important raw material, and Knife River Flint the most important exotic (Table 3-4).

The subregion is dominated by glacial sediment. It is entirely within the Des Moines lobe domain, and more specifically is dominated by tills of the Erskine Moraine (Hobbs and Goebel 1982). Note, however, that the tills in this region may not be as uniform as the large scale maps suggest. The tills in western Roseau County, for example, contain sometimes-abundant clasts of Swan River and Red River cherts. The tills in southeastern Roseau County and on into Lake of the Woods County, in contrast, seem to lack these materials and instead contain quartz and granitic rock more characteristic of the Rainy lobe.

The subregion is also characterized by large areas of Agassiz lakebed that is essentially stone free, especially in the parts of the subregion near the Red River. Several series of beach ridges provide potential toolstone sources. The eastern reaches include large areas of peat

Table 3-5. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for South Agassiz Resource Region as a whole and for subregions; all figures are for county-wide aggregations.

	South Agassiz Region	*Tamarack Subregion*	*Upper Red Subregion*	*Shetek Subregion*
South Agassiz Materials	**61.8**	***82.0*** **74.5** *44.7*	*73.8* **53.9** *34.9*	*78.9* **51.2** *32.3*
Red River Chert	**14.9**	*27.4* **19.6** *3.2*	*43.1* **13.6** *5.5*	*12.9* **6.5** *0.9*
Silicified Wood	**0.1**	*0.2* **0.1** *0.0*	*0.3* **0.2** *0.0*	*1.3* **0.1** *0.0*
Swan River Chert	**46.8**	***75.5*** **54.9** *20.3*	*62.2* **40.1** *24.2*	*78.1* **44.5** 23.7
West Superior Materials	**1.1**	*5.9* **1.4** *0.2*	*6.8* **0.9** *0.0*	*6.5* **1.2** *0.0*
Animikie Group (*not specified*)	**0.0**	*1.2* **0.0** *0.0*	*0.2* **0.0** *0.0*	*0.0* **0.0** *0.0*
Gunflint Silica	**0.5**	*1.7* **0.0** *0.2*	*0.9* **0.3** *0.0*	*5.5* **0.5** *0.0*
Hudson Bay Lowland Chert	**0.4**	*4.1* **0.6** *0.0*	*6.8* **0.4** *0.0*	*0.7* **0.0** *0.0*
Jasper Taconite	**0.1**	*0.5* **0.1** *0.0*	*0.4* **0.1** *0.0*	*1.0* **0.**2 *0.0*
Kakabeka Chert	**0.0**	*0.0* **0.0** *0.0*	*0.4* **0.0** *0.0*	*0.0* **0.0** *0.0*
Lake Superior Agate	**0.1**	*0.1* **0.0** *0.0*	*0.4* **0.0** *0.0*	*1.1* **0.4** *0.0*
Hollandale Materials	**2.1**	*1.3* **0.1** *0.0*	*6.9* **1.6** *0.0*	*21.4* **8.7** *2.0*
Cedar Valley Chert	**0.2**	*0.0* **0.0** *0.0*	*1.7* **0.3** *0.0*	*1.8* **0.4** *0.0*

Table 3-5. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for South Agassiz Resource Region as a whole and for subregions; all figures are for county-wide aggregations.

	South Agassiz Region	*Tamarack Subregion*	*Upper Red Subregion*	*Shetek Subregion*
Galena Chert	**0.2**	*0.1* **0.0** *0.0*	*0.9* **0.3** *0.0*	*2.0* **0.3** *0.0*
Grand Meadow Chert	**0.4** *0.0*	*0.3* **0.0** *0.0*	*2.2* **0.3** *0.0*	*9.4* **1.7** *0.4*
Prairie du Chien Chert	**1.3**	*1.2* **0.1** *0.0*	*2.8* **0.6** *0.0*	*14.7* **6.3** *0.3*
Shell Rock Chert	**0.0**	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*
Pipestone Materials	**0.0**	*0.0* **0.0** *0.0*	*0.4* **0.0** *0.0*	*1.1* **0.2** *0.0*
Gulseth Silica	**0.0**	*0.0* **0.0** *0.0*	*0.4* **0.0** *0.0*	*1.1* **0.2** *0.0*
Tongue River Silica	**5.2**	*9.1* **1.4** 0.0	*37.0* **7.5** *1.6*	*22.0* **8.8** *0.9*
Quartz	**5.6**	*12.1* **2.6** *0.3*	*19.6* **7.1** *0.8*	*19.8* **9.3** *0.3*
Border Lakes Greenstone Group	**3.3**	*18.6* **3.9** 0.4	*13.4* **3.5** *0.4*	*3.9* **1.5** *0.0*
Knife Lake Siltstone	**0.7**	*3.0* **0.4** *0.0*	*6.6* **1.1** *0.0*	*1.6* **0.5** *0.0*
Lake of the Woods Chert	**0.2**	*0.9* **0.1** *0.0*	*2.8* **0.3** *0.0*	*0.0* **0.0** *0.0*
Lake of the Woods Rhyolite	**2.4**	*14.7* **3.3** *0.0*	*7.1* **2.1** *0.0*	*3.2* **0.9** *0.0*
Western River Gravels Group	**0.1**	*0.2* **0.0** *0.0*	*0.3* **0.0** *0.0*	*0.5* **0.3** *0.0*

Table 3-5. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for South Agassiz Resource Region as a whole and for subregions; all figures are for county-wide aggregations.

	South Agassiz Region	*Tamarack Subregion*	*Upper Red Subregion*	*Shetek Subregion*
Sioux Quartzite Group	**0.0**	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*	*0.3* **0.1** *0.0*
Sioux Quartzite	**0.0**	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*	*0.3* **0.1** *0.0*
Other (*cf. chopping tool materials*)	**1.5**	*6.3* **2.6** *0.0*	*1.0* **0.7** *0.0*	*1.8* **0.7** *0.0*
Generic Identifications	**9.7**	*15.2* **7.3** *4.4*	*16.6* **10.6** *3.0*	*23.9* **13.4** *4.2*
Exotic Materials	**7.6**	*18.0* **6.1** *2.1*	*21.9* **10.1** *1.4*	*10.4* **4.5** *0.3*
Burlington Chert	**0.2**	*0.1* **0.0** *0.0*	*0.3* **0.1** *0.0*	*2.0* **0.8** *0.0*
Hixton Quartzite	**0.1**	*0.0* **0.0** *0.0*	*0.5* **0.2** *0.0*	*1.7* **0.1** *0.0*
Knife River Flint	**7.2**	*18.0* **6.0** *2.1*	*21.6* **9.7** *1.4*	*8.3* **3.4** *0.3*
Obsidian	**0.0**	*0.2* **0.0** *0.0*	*0.3* **0.0** 0.0	*0.5* **0.2** *0.0*
Nonlocal Materials	**1.9**	*0.2* **0.1** *0.0*	*9.7* **4.2** *0.0*	*1.8* **0.4** *0.0*
Fusilinid Group				
Maynes Creek Chert				

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one subregion; other materials may occur but are not specifically listed. Counties spanning more than one resource region are included in statewide figures, but not regional figures.

bogs, where raw material accessibility is probably limited. Note, however, that this has only been the case since the formation of the peatlands 3,000 to 4,000 years ago (Wright et al. 1992). Prior to that, patterns of raw material availability may have been different.

There are some bedrock outcrops in the northeastern corner of this subregion, beginning around Lake of the Woods. Observed outcrops are granitic, and thus not generally relevant in terms of raw material resources. Note, however, that flakeable stone (including rhyolites, cherts and possibly other materials) are found around the northern reaches of Lake of the Woods in Ontario, a relatively short distance to the north.

The primary lithic raw materials associated with the Tamarack Subregion include Swan River Chert and Red River Chert (Tables 3-4, 3-5). Swan River Chert (Appendix 1-4) is more common, and occurs in a variety of sizes ranging from pebbles to small boulders. Red River Chert (Appendix 1-2) occurs in sizes ranging from pebbles to mid-sized cobbles. These often have cracks or other flaws, so this raw material was not generally as valuable a resource as Swan River Chert.

Secondary raw materials include quartz (Appendix 1-22) and Lake of the Woods Rhyolite (Appendix 1-25). Quartz (Appendix 1-22) occurs widely in the subregion, although it is more likely to occur as pebbles to small cobbles in the west; in the east, it may be more abundant and have the form of pebbles to large cobbles. The glacial distribution of Lake of the Woods Rhyolite is not clear, but it may be more abundant to the east. It is commonly found as fist-sized cobbles, although small boulders are occasionally found.

Minor raw materials include smaller pieces of unidentified jaspers, cherts, silicified wood (Appendix 1-3) and possibly other raw materials (Appendix 1-31). Some of these probably represent the Western River Gravels Group (Appendix 1-27). Note that Tongue River Silica (Appendix 1-21) is absent, in contrast to the other subregions of the South Agassiz Resource Region.

Knife River Flint (Appendix 1-32) is clearly the most important exotic material in the subregion. At a few sites, it is even the most common raw material. Obsidian (Appendix 1-33) occurs in small amounts at some sites.

Upper Red Subregion

The Upper Red Subregion includes all or parts of 13 counties in west-central Minnesota (Figure 2-3, Table 3-2). The subregion continues into eastern North Dakota and northeastern South Dakota, but the limits of the subregion are not defined outside of

Minnesota. The subregion is dominated by glacial sediment, although near the Red River large areas in the Agassiz lakebed are essentially stone free. There are no bedrock outcrops. Swan River Chert is the most important raw material, and Knife River Flint the most important exotic (Table 3-4).

The glacial sediment includes both Des Moines and Wadena lobe tills (Hobbs and Goebel 1982). More specifically, it primarily includes tills associated with the Erskine and Big Stone moraines (Red River), and the Itasca and Alexandria moraines (Wadena), while smaller areas are associated with the Altamont moraine (Des Moines).

The subregion is also characterized by areas of Agassiz lakebed that are largely stone free, especially in the parts of the subregion near the Red River. Several series of beach ridges provide potential toolstone sources. Bedrock outcrops are apparently entirely absent in this subregion.

The primary lithic raw materials associated with the Upper Red Subregion include Swan River Chert and Red River Chert (Tables 3-4, 3-5). Swan River Chert (Appendix 1-4) is more common, and occurs in a variety of sizes ranging from pebbles to small boulders. Red River Chert (Appendix 1-2) occurs in sizes ranging from pebbles (common) to small cobbles (rare). These often have cracks or other flaws, so this raw material was not generally as valuable a resource as Swan River Chert.

Secondary raw materials include quartz, Lake of the Woods Rhyolite and Tongue River Silica. Quartz (Appendix 1-22) occurs widely in the subregion, although it is more common to the east in the areas with surficial till. Lake of the Woods Rhyolite (Appendix 1-25) most likely occurs in this subregion, and likely in smaller amounts than in the Tamarack Subregion to the north. Tongue River Silica (Appendix 1-21) also occurs, apparently in most of the subregion; it may be common to abundant in the eastern parts of the subregion, where it might also occur as larger pieces.

Minor raw materials include local Knife River Flint, smaller pieces of unidentified jaspers, cherts, silicified wood (Appendix 1-3) and possibly other raw materials (Appendix 1-29). Some of these probably represent the Western River Gravels Group (Appendix 1-27). Here as in some other parts of Minnesota, KRF occurs as scattered, small pieces that constitute a minor raw material resource. Most KRF found at regional sites likely comes from the primary source area to the northwest.

Knife River Flint (Appendix 1-32) is clearly the most important exotic material in the subregion. At a few sites, it is even the most common raw material. Obsidian (Appendix 1-33) occurs in small amounts at some sites.

Shetek Subregion

The Shetek Subregion includes all or parts of 25 counties in central to southwestern Minnesota (Figure 2-3, Table 3-2). The subregion continues into eastern South Dakota and northern Iowa, but the limits of the subregion are not defined outside of Minnesota. The subregion is dominated by glacial sediment. Scattered bedrock outcrops occur, especially along the Minnesota and possibly other deeply incised rivers. Swan River Chert is the most important raw material, and Knife River Flint the most important exotic. Prairie du Chien Chert (PdC) is also important in the subregion (Table 3-4).

The glacial sediment includes both Des Moines and Wadena lobe tills (Hobbs and Goebel 1982). More specifically, it primarily includes tills associated with the Altamont and Bemis moraines, smaller areas associated with the Pine City moraine (in the northeastern part of the region), with undifferentiated outwash and glacial lake sediment (Des Moines); plus tills associated with the Alexandria moraine (Wadena). In addition, different (and generally older) tills are exposed along the Minnesota River Valley. Among these are the Hawk Creek, Granite Falls and New Ulm tills, and possibly other less-well known tills (Matsch 1972:552-554). Hawk Creek is a reddish till with origin to the northeast in the Lake Superior region. The origin of the Granite Falls till in not clear, but it is similar to the Wadena lobe tills found to the north.

Although most of this region is blanketed in till, bedrock exposures are known in some areas, especially along parts of the Minnesota River Valley. At New Ulm, for example, outcrops of a basal conglomerate of the Sioux Quartzite contain potentially flakeable clasts of chert, jasper and quartz. Grant (1972) provides an overview of bedrock exposures in the region.

The primary lithic raw materials associated with the Shetek Subregion include Swan River Chert and Tongue River Silica (Tables 3-4, 3-5). Swan River Chert (Appendix 1-4) is more common, and probably occurs in a variety of sizes ranging from pebbles to small boulders. Tongue River Silica (Appendix 1-21) probably occurs as pebbles and cobbles in most surficial sediments. Although the evidence is somewhat ambiguous, TRS may also occur in older tills that are erosionally exposed in the Minnesota River Valley. If these tills correlate with the older tills exposed past the eastern and western margins of the Des Moines lobe, they may well contain more abundant and larger clasts of TRS.

Secondary raw materials include Red River Chert and quartz. Red River Chert (Appendix 1-2) may occur only as pebbles, although the presence of cobbles cannot be ruled out. No specific information is available on quartz (Appendix 1-22) in the region. Based on broader patterns of distribution, however, low-quality quartz is probably present as pebbles and possibly cobbles.

Minor raw materials include Knife River Flint, Sioux Quartzite, and Sioux Conglomerate Group materials. Here as in some other parts of Minnesota, KRF occurs as scattered, small pieces that constitute a minor raw material resource. Most KRF found at regional sites likely comes from the primary source area to the northwest. Sioux Quartzite (Appendix 1-20) crops out in the Shetek Subregion, and clasts are probably also available from glacial sediment. Its relative abundance has not been assessed. It is listed here as a minor raw material, however, because it is poorly suited as a toolstone and apparently only rarely used. The Sioux Conglomerate Group materials are considered to be minor raw materials because of their very limited availability. At present, only two outcrops are known, one at New Ulm in Nicollet County and one near Pipestone in Pipestone County (Austin 1972:452). Minor raw materials also include unidentified jaspers, cherts, silicified wood (Appendix 1-3) and possibly other raw materials (Appendix 1-29). Some of these probably represent the Western River Gravels Group (Appendix 1-27).

The role of Prairie du Chien Chert (Appendix 1-16) in the Shetek Subregion requires some mention. In a sense, PdC could almost be considered a "local" material. The closest PdC sources are probably on the eastern edge of the Shetek Subregion, in the vicinity of Mankato, and Nicollet and Blue Earth counties. These sources are actually in the Hollandale Resource Region, where PdC is properly considered a primary local material. However, PdC is a significant resource in the Shetek Subregion, and it is in fact the common archaeological occurrence of PdC that helps separate the Shetek Subregion from the Upper Red and Tamarack subregions.

Knife River Flint (Appendix 1-32) is clearly the most important exotic material in the subregion. At a few sites, it is even the most common raw material. Burlington Chert (Appendix 1-30) is also a noteworthy exotic in the subregion. Obsidian (Appendix 1-33) occurs in small amounts at some sites.

West Superior Resource Region

The West Superior Resource Region includes all or parts of 23 counties in central to northeastern Minnesota (Figure 2-3, Table 3-2). The region continues into northwestern Ontario and possibly northern Wisconsin. The limits of the region are not defined, however, outside of Minnesota. Glacial sediment is abundant in the region, especially to the south. Bedrock outcrops are also common, generally more so to the northeast. Gunflint Silica, Knife Lake Siltstone and quartz are the most important raw materials; Knife River Flint, Hixton Group quartzites and Burlington Chert are all important exotics in various parts of the region (Table 3-4).

The region includes deposits of Rainy, Superior, Des Moines and Wadena lobe tills, as well as bedrock outcrops. In general, till sources are most important as raw material sources in the southwest part of the region, while bedrock sources grow more common and more important to the northeast. Some of the associated materials are found throughout all or most of the region, while others are not. In general, raw material availability is less homogenous in the West Superior Region than in the other resource regions.

The Rainy and Superior lobes represent several stages of ice advance from the northeast. The two sets of tills are quite distinct. Rainy lobe till tends to be lighter in color, generally brownish to greyish, and contains a variety of materials derived from the Canadian shield. In particular these include various igneous and metamorphic types, although sedimentary rocks are also represented. Superior lobe tills, in contrast, are noticeably red in color. The till also includes an assortment of igneous and metamorphic rocks, with some sedimentary clasts. The Wadena lobe, as discussed above, is thought to be part of the Rainy lobe. The till is distinct from other Rainy lobe tills, however, because it incorporated significant amounts of northwestern-source sediment from previously-deposited glacial tills (Goldstein 1985).

The Des Moines lobe sediments represent several stages of ice advance from the northwest and the vicinity of the Winnipeg lowlands. These tills are generally light brown, calcareous and have a strong component of sedimentary rock. It is likely that the Des Moines lobe till found within the northern part of the West Superior Region is diluted by the incorporation of earlier tills of northeastern origin, possibly associated with the Rainy lobe. If this is the case, it would mean that South Agassiz Group raw materials (e.g., Swan River and Red River cherts) are less common here than they would be in corresponding sediment in the South Agassiz Region. Note that this is not as much of a factor in the southern parts of the West Superior Region.

The relative importance of various raw materials depends on what part of the region you are looking at, and what time period (Tables 3-4, 3-6). Jasper Taconite (Appendix 1-9), for example, is a primary raw material in the northeastern part of the region near outcrop sources, and especially for Paleoindian sites. In the southern parts of the region, however, it is only a minor raw material. Knife Lake Siltstone (KLS; Appendix 1-24) is a primary raw

Table 3-6. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for West Superior Resource Region as a whole and for subregions; all figures are for county-wide aggregations.

	West Superior Region	*Arrowhead Subregion*	*Quartz Subregion*
South Agassiz Materials	**4.4**	*11.2* **0.6** *0.0*	*23.8* **5.4** *0.3*
Red River Chert	**0.9**	*3.2* **0.2** *0.0*	*4.2* **1.0** *0.0*
Silicified Wood	**0.0**	*0.0* **0.0** *0.0*	*0.2* **0.0** *0.0*
Swan River Chert	**3.5**	***8.0*** **0.5** *0.0*	*20.1* **4.3** *0.1*
West Superior Materials	**9.2**	*76.7* **23.8** *15.1*	*15.5* **5.1** *0.0*
Animikie Group (*not specified*)	**1.1**	*18.2* **4.7** *1.3*	*0.8* **0.1** *0.0*
Gunflint Silica	**2.3**	*40.9* **7.3** *4.2*	*7.1* **0.8** *0.0*
Hudson Bay Lowland Chert	**1.6**	12.9 **5.5** *1.6*	*5.5* **0.5** *0.0*
Jasper Taconite	**3.2**	*8.2* **5.3** *1.5*	*9.0* **2.6** *0.0*
Kakabeka Chert	**0.4**	*1.0* **0.8** *0.0*	*4.4* **0.3** *0.0*
Lake Superior Agate	**0.6**	*0.6* **0.1** *0.0*	*3.0* **0.7** *0.0*
Hollandale Materials	**2.1**	*0.1* **0.0** *0.0*	*24.3* **2.7** *0.0*
Cedar Valley Chert	**0.3**	*0.0* **0.0** *0.0*	*5.1* **0.4** *0.0*

Table 3-6. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for West Superior Resource Region as a whole and for subregions; all figures are for county-wide aggregations.

	West Superior Region	*Arrowhead Subregion*	*Quartz Subregion*
Galena Chert	**0.0**	*0.0* **0.0** *0.0*	*0.7* **0.1** *0.0*
Grand Meadow Chert	**0.1**	*0.0* **0.0** *0.0*	*0.4* **0.1** *0.0*
Prairie du Chien Chert	**1.7**	*0.0* **0.0** *0.0*	*19.1* **2.2** *0.0*
Shell Rock Chert	**0.0**	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*
Pipestone Materials	**0.0**	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*
Gulseth Silica	**0.0**	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*
Tongue River Silica	**9.7**	*1.6* **0.1** 0.0	*39.7* **12.3** *0.1*
Quartz	**50.1**	23.8 **9.2** *1.3*	*93.3* **61.5** *23.2*
Border Lakes Greenstone Group	**16.1**	*65.9* **58.7** *5.0*	*14.5* **4.3** *0.0*
Knife Lake Siltstone	**14.7**	*64.4* **56.0** *3.8*	*12.4* **3.2** *0.0*
Lake of the Woods Chert	**0.0**	*0.0* **0.0** *0.0*	*0.2* **0.0** *0.0*
Lake of the Woods Rhyolite	**1.4**	*26.6* **2.7** *1.3*	*3.5* **1.1** *0.0*
Western River Gravels Group	**0.0**	*0.0* **0.0** *0.0*	*0.3* **0.0** *0.0*

Table 3-6. Intensity of use for selected lithic raw materials showing maximum, average and minimum percentages, for West Superior Resource Region as a whole and for subregions; all figures are for county-wide aggregations.

	West Superior Region	*Arrowhead Subregion*	*Quartz Subregion*
Sioux Quartzite Group	**0.0**	*0.0* **0.0** *0.0*	*3.7* **0.0** *0.0*
Sioux Quartzite	**0.0**	***0.0*** **0.0** *0.0*	*3.7* **0.0** *0.0*
Other (*cf. chopping tool materials*)	**1.3**	*2.8* **2.4** *0.0*	*16.5* **1.0** *0.0*
Generic Identifications	**5.4**	*4.9* **3.7** *1.3*	*13.3* **5.8** *2.0*
Exotic Materials	**1.8**	*15.7* **1.4** *1.0*	*19.0* **1.9** *0.0*
Burlington Chert	**0.1**	*0.0* **0.0** *0.0*	*0.8* **0.1** *0.0*
Hixton Quartzite	**0.4**	*0.7* **0.4** *0.0*	*3.3* **0.4** *0.0*
Knife River Flint	**1.3**	*15.7* **1.0** *0.6*	*19.0* **1.3** *0.0*
Obsidian	**0.0**	*0.0* **0.0** *0.0*	*0.3* **0.0** 0.0
Nonlocal Materials	**0.0**	*0.0* **0.0** *0.0*	*0.0* **0.0** *0.0*
Fusilinid Group			
Maynes Creek Chert			

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one subregion; other materials may occur but are not specifically listed. Counties spanning more than one resource region are included in statewide figures, but not regional figures.

material throughout the region, but only for Paleoindian sites. After that point, it becomes much less important. Quartz (possibly Fat Rock Quartz; Appendix 1-22) is probably the single most important raw material in the southern half of the region – again after the Paleoindian period. Gunflint Silica (and maybe Biwabik Silica) (Appendix 1-7) could be considered a primary raw material in some times and places, a minor raw material in others. Other materials found in the region – Lake of the Woods Rhyolite (Appendix 1-25), Kakabeka Chert (Appendix 1-10), Hudson Bay Lowland Chert (Appendix 1-8) and Lake Superior Agate (Appendix 1-11) – might be variously considered secondary to minor. The role of other rhyolites and of basalt remain to be understood.

Knife River Flint (Appendix 1-32) and Hixton Group quartzites (Appendix 1-31) occur in the northern parts of the region, although there are chronological differences in their occurrence and neither are terribly common. Both also occur in the southern parts of the region, along with some Burlington Chert. Obsidian (Appendix 1-33) occurs in small amounts at some sites, mostly in the southern parts of the region.

Arrowhead Subregion

The Arrowhead Subregion includes all or parts of five counties in northeastern Minnesota (Figure 2-3, Table 3-2). The subregion continues into northwestern Ontario and possibly northern Wisconsin. The limits of the subregion are not defined, however, outside of Minnesota. Both glacial sediment and bedrock outcrops occur in the region. Generally speaking, bedrock outcrops are more important to the north and east, with glacial sediment increasingly important to the south and west. The relative importance of various raw materials, whether local or nonlocal, is somewhat complicated in the Arrowhead Subregion; this is discussed in further detail below.

The subregion includes deposits of Rainy, Superior and Des Moines lobe tills, as well as bedrock outcrops. More specifically this includes the Vermillion, Nashwauk and St. Croix (Rainy) moraines; Itasca and Alexandria (Wadena) moraines; Nickerson, Cloquet (Superior); and Erskine, Culver and Sugar Hills (Des Moines) moraines. In short, the subregion is something of a till smorgasbord. Note, however, that the Des Moines lobe tills do not seem to contribute substantially to raw material provisioning in the subregion since they are significantly diluted with Rainy lobe or other tills. There are also areas of peat, outwash, and glacial lake sediment.

Bedrock is a significant factor in toolstone availability in the Arrowhead subregion. In general, bedrock outcrops become more significant to the north and east, and glacial sediment more significant to the west and south. The distribution of toolstone outcrops is incompletely known, but includes sources of Fat Rock Quartz, Jasper Taconite, Kakabeka Chert, Knife Lake Siltstone, and possibly other raw materials.

Because the raw material resource base is less homogenous in the Arrowhead Subregion, it is more difficult to rank the relative importance of different raw materials (Tables 3-4, 3-6). Jasper Taconite (Appendix 1-9), for example, is of primary importance where it crops out near Thunder Bay, but less important to the south with increasing distance from the bedrock source. That said, it appears that the primary lithic raw materials associated with the Arrowhead Subregion include Biwabik Silica, Gunflint Silica (Appendix 1-7), Jasper Taconite (Appendix 1-9), Kakabeka Chert (Appendix 1-10), Knife Lake Siltstone (Appendix 1-24), and (till) quartz (Appendix 1-22). The first four of these are Animikie Group silicates (Appendix 1-6), and are associated with iron formation in Minnesota and Ontario. Some outcrops are known, and some of these bear evidence of raw material extraction. Jasper Taconite and Kakabeka Chert outcrop in the vicinity of Thunder Bay (Hinshelwood and Webber 1987:27), and Steinbring (1974:67-68) alludes to a nineteenth century report of a "quarry" in St. Louis County, Minnesota. Romano (1994c:6) discusses a report of a possible Gunflint Silica (GFS) or Biwabik Silica outcrop near Virginia. Knife Lake Siltstone occurs in outcrops along parts of the Minnesota-Ontario border in Quetico Provincial Forest and the Boundary Waters Canoe Area, and there is clear evidence for raw material extraction at many of these locations (Clayton and Hoffman 2009; Nelson 1992, 2003). The Animikie Group silicates are also available over a wider area as clasts in glacial sediment, while KLS is abundant in glacial sediment over a much wider area. Quartz is available in the region in glacial sediment and possibly from bedrock exposure. Its origins, characteristics and abundance are not well known, however.

Secondary raw materials include Hudson Bay Lowland Chert, and maybe Lake of the Woods Siltstone (Appendix 1-26) and Lake of the Woods Rhyolite. The regional distribution of Hudson Bay Lowland Chert remains somewhat enigmatic, probably in part because of some confusion surrounding identification of the material. The natural occurrence of HBLC has been reported for Minnesota, but its range and abundance remain unclear. It may be that much of the HBLC found at Minnesota sites came from better sources in northwestern Ontario. There is some uncertainty regarding the distribution, use and importance of Border Lakes Greenstone Group materials (Appendix 1-23) in the Arrowhead

Subregion. In part this is because of the muddied relationship between the two siltstones, and the difficulty in consistently distinguishing between Lake of the Woods Siltstone and Lake of the Woods Rhyolite. It is clearly present in the western part of the Arrowhead Subregion (e.g., 21IC31), and may in fact be more important there than is suggested here.

Minor raw materials include Lake Superior Agate (LSA; Appendix 1-11), basalt, rhyolite, Swan River Chert (Appendix 1-4), and Red River Chert (Appendix 1-2). Lake Superior Agate originated in amygdaloidal basalts around Lake Superior (Pabian and Zarins 1994; Wolter 1996). Although LSA is distributed over a wide area, it is probably more abundant in the Arrowhead and Quartz subregions than in other areas. Poorly understood basalts and rhyolites are also found in the region. They may in fact prove to be more important than indicated here, but this is difficult to assess based on currently available information. Rhyolite outcrops occur at multiple locations along the North Shore of Lake Superior (e.g., Ojakangas and Matsch 1982), and there may be widespread basalt outcrops also. Swan River Chert and Red River Chert should be present, probably in limited amount, in those parts of the Arrowhead Subregion where geologic mapping indicates till of northwestern origin. Archaeological evidence indicates that they are not regionally important, however, and that their importance rapidly declines from west to east across the region. This may reflect dilution of the northwestern-source till with earlier northeastern-source till and an attendant dilution in the abundance of these South Agassiz Group raw materials, or the effect could be mostly related to human transportation of the materials.

Knife River Flint (Appendix 1-32) and Hixton Group quartzites (Appendix 1-33->31) occur, although there are chronological differences in their occurrence and neither are terribly common. Obsidian (Appendix 1-33) is rare.

Quartz Subregion

The Quartz Subregion includes all or part of 18 counties in central to east-central Minnesota (Figure 2-3, Table 3-2). The subregion likely continue into northwestern Wisconsin. The limits of the resource region are not defined, however, outside of Minnesota. This region is generally dominated by glacial sediment, although scattered bedrock outcrops are not uncommon. Knife Lake Siltstone and quartz (especially Fat Rock Quartz) are the most important raw materials; Knife River Flint, Hixton Group quartzites and Burlington Chert are all important exotics in various parts of the region (Table 3-4).

The glacial sediment includes deposits of Rainy, Superior, and Wadena till (Hobbs and Goebel 1982). More specifically these are associated with the St. Croix, Cloquet and Mille-Lacs Highland (Superior) moraines; St. Croix (Rainy); and Itasca and Alexandria (Wadena) moraines. Des Moines lobe till also occurs in the region, although its distribution and importance require some explanation. In the northern part of the Quartz Subregion, there are sizeable areas associated with the Erskine, Culver and Sugar Hills moraines. South Agassiz Group raw materials, normally strongly associated with Des Moines tills, seem to be of minor importance here. This suggests some dilution of the Des Moines lobe tills with previous (possibly Rainy lobe) sediment. The situation is different in the southern part of the subregion, where its approximate boundaries are drawn through an area of Des Moines lobe tills (Altamont and Pine City). In the southernmost part of the subregion, South Agassiz materials are definitely important and their importance increases rapidly along a north-to-south gradient. In addition to the glacial sediment, there are some bedrock outcrops that served or may have served as toolstone sources. The most important of these may have been outcrops at Little Falls that contain seams of Fat Rock Quartz.

The primary raw materials associated with the Quartz Subregion are Knife Lake Siltstone, Tongue River Silica, Fat Rock Quartz and other quartz (Tables 3-4, 3-6). Knife Lake Siltstone (Appendix 1-24) is especially important throughout the subregion in Paleoindian sites, but less so in later-period sites. Tongue River Silica (Appendix 1-21) is an important resource in the western part of the subregion, but is essentially absent in the easternmost part. Quartz (Appendix 1-22), however, is the central raw material in this subregion (hence the subregion's name). This includes the quite-flakeable Fat Rock Quartz from the vicinity of Little Falls in Morrison County, as well as less-flakeable quartz of other origins that is more widely distributed around the subregion. The present problem, however, is that Fat Rock and other kinds of quartz are not separated in our lithic data. This compromises our ability to analyze and understand the use of quartz.

Secondary raw materials include Swan River Chert (Appendix 1-4). Much like TRS, Swan River is an important resource in the western part of the subregion, but minor in the easternmost part.

Minor raw materials include Biwabik Silica, Gunflint Silica (Appendix 1-7), Jasper Taconite (Appendix 1-9), Kakabeka Chert (Appendix 1-10), Hudson Bay Lowland Chert (Appendix 1-8), Lake Superior Agate (Appendix 1-11), and Lake of the Woods Rhyolite (Appendix 1-25). These materials normally constitute only a small percent of lithic assemblages in the subregion. Note, however, that Lake Superior Agate is used to a greater extent in the Quartz Subregion than in any other part of the state.

In addition, there are reports of the use of a rhyolite that has not been specifically defined (Goltz, personal communication 6 February 2001), but at this point little is known about its characteristics, distribution or prevalence of use. In addition, one might expect to find some use of the rhyolite that outcrops along the North Shore, distributed here to the south in Superior Lobe tills. This also requires further investigation.

Knife River Flint (Appendix 1-32) is probably the most common exotic material in the subregion, although it is not especially abundant. In some cases, Hixton Group quartzites (Appendix 1-31) or Burlington Chert (Appendix 1-30) may be more abundant. Obsidian (Appendix 1-33) occurs in small amounts at some sites.

Pipestone Resource Region

The Pipestone Resource Region includes all or part of two counties in extreme southwestern Minnesota (Figure 2-3, Table 3-2), three counties in eastern South Dakota, and an undetermined number of counties in northwestern Iowa (see Hobbs and Goeble 1982; Lineburg 1993:Fig. 6; Prior 1976). The limits of the region seem fairly clear in Minnesota and South Dakota but require further exploration in Iowa. This region is dominated by glacial sediment, although scattered bedrock outcrops occur. Tongue River Silica is an important raw material in the region, and Knife River Flint the most important exotic (Table 3-4).

Pre-Late Wisconsin tills predominate in the region. Missouri River gravels may serve as a secondary source of raw materials in the northwestern Iowa part of the region. Bedrock outcrops are limited to scattered outcrops of Sioux Quartzite. The Pipestone Resource Region is bounded on the east by the Des Moines lobe tills of the Shetek Subregion, South Agassiz Region. On the west it is bounded by the Dakota till of the James lobe. One interesting feature found in part of the region is the Iowa Erosional Surface, a pebble and cobble lag deposit (Lineburg 1993:15). To the degree that this surface was exposed, may have potentially served as a raw material source (depending also on the composition of the clasts it contains).

The Pipestone Resource Region is defined as beginning beyond the margins of the Toronto till and Bemis moraine. The region beyond this border consists of older till plains, namely the Crooks till plain-Iowa Erosional Surface to the south and Brookings till plain to the north. Crooks till is exposed at the surface in most of the prior geomorphic region, and a poorly known till in the latter. Although these till plains are clearly bounded on the west by moraines and tills of the James lobe, a western border is not proposed for the regions. This is because the raw material content of these tills is poorly known; similar content would argue for these tills being grouped in a single region, while differing content would argue for the definition of a new region beginning at the margins of the James lobe till.

Note also that the Toronto till plain is not included in the Pipestone Resource Region for two reasons. First, the Toronto till in this geomorphic region is characterized as being similar to the Des Moines lobe tills immediately to its east, suggesting that it would contain similar raw material resources (a characterization that is upheld by the distributions of archaeological lithic data). In addition, Lineburg (1993) notes that the Toronto till plain has a loess mantle, which would presumably limit access to the raw materials it contains except perhaps in erosional features.

Since multiple tills of various ages are present in this region, it is possible that the availability of raw materials varies across the region. According to Lineburg (1993), there are five pre-Late Wisconsin till units exposed in the Pipestone Resource Region, ranging in age from 30,000 or 40,000 years to over 700,000 years. In general these sediments are capped with loess of variable thickness. These have a variety of mixed lithologies, indicating origin for the glacial sediments from various directions ranging from northwest to northeast. They range from clast-poor to clast-rich. These might be expected to yield different suites of raw materials, although determining whether or not this is the case will require field survey and sample collection.

I am aware of only very limited sampling of flakeable stone in this resource region to date, so the raw material resources of this region are not well known. Anecdotal and archaeological lithic evidence suggests that Tongue River Silica is present in the region, and probably abundant (e.g., Anderson 1980). Anderson (1980:200), regarding Bijou Hills Quartzite,[4] notes that "small quantities are present in northwest Iowa gravels," which suggests that this material should be associated with the Pipestone Region. Bijou Hills is absent in the (admittedly limited) lithic sample from the region, however. This raises the question of whether Anderson meant that Bijou Hills was present in Missouri River gravels rather than glacial sediment. Sites in Rock and Pipestone counties of southwestern Minnesota have also

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[4] Church (1994) recommends the term Ogallala orthoquartzite, and expands its definition to include materials that would not be included in the regular definition of Bijou Hills Quartzite. The terminology recommended in this thesis suggests that the term Ogallala Group might be appropriate instead.

yielded a poorly understood material called Gulseth Silica (Skaar et al. 1994). Efforts are being made to better define this material, including its petrography, distribution and potential source. To date, however, the results are not available.

Tongue River Silica (Appendix 1-21) is a primary raw material in the region (Table 3-4). Gulseth Silica (Appendix 1-19) and Sioux Quartzite (Appendix 1-20) are probably secondary raw materials. Quartz (Appendix 1-22) is a minor raw material. Note that this list is most likely incomplete, since we have limited information on the suite of raw materials occurring in the region. Knife River Flint (Appendix 1-32) is the most common exotic. No information is available on the occurrence of obsidian.

Hollandale Resource Region

The Hollandale Resource Region includes all or parts of 25 counties in east-central to southeastern Minnesota (Figure 2-3, Table 3-2). It continues into west-central to southwestern Wisconsin and into northeastern Iowa. The limits of the region are not defined, however, outside of Minnesota. Glacial sediment dominate the western part of the region, but bedrock also crops out in eroded valleys. In contrast, glacial sediment constitutes a minor eroded residuum to the east, where the landscape is dominated by loess-mantled terrain and bedrock exposures in eroded valleys. Cedar Valley, Galena, Grand Meadow and Prairie du Chien cherts are the most important raw materials, and Hixton Group quartzites are the most important exotics (Table 3-4).

The region includes large areas of Des Moines lobe, smaller areas of Superior Lobe and old tills, plus a region where traces of glaciation are scant and raw materials are mostly available from primary geologic contexts. This sounds too diverse to constitute a single resource region, but a couple of factors serve to unify the region. First, erosion along regional streams has exposed significant bedrock raw material sources, even in some areas that are generally mantled with glacial till. It appears that to some degree there was a preference for the bedrock sources (although this may have varied between use patterns). Second, it seems possible that some of the raw materials found in local bedrock have been incorporated in glacial sediment and more broadly distributed in tills.

While we can argue for a certain degree of unity for this region, there is also a significant degree of heterogeneity. Most of this is related to the differential distributions of the raw materials available from primary geologic sources. These sources have geographic dispositions that do not easily lend themselves to regionalization, but can more easily be defined in terms of raw material "hot spots." The Hollandale Resource Region is not subdivided here, since the parts of the region that extend into Iowa and Wisconsin have not been examined for this study. A broader look at the region could easily lead to the definition of analytically useful subregions.

The primary raw materials associated with the Hollandale Resource Region include Galena Chert, Prairie du Chien Chert, Cedar Valley Chert (CVC) and Grand Meadow Chert (GMC) (Table 3-4). Prairie du Chien Chert (Appendix 1-16) is the most important raw material in large parts of the region. It appears that PdC sources are arranged approximately around the northwestern to northern edges of the region and then down the Mississippi River Valley, forming a sort of crescent. Cedar Valley (Appendix 1-13) and Grand Meadow (Appendix 1-15) cherts are most important in the south-central part of the region, especially in the vicinity of Freeborn and Mower counties. Galena Chert (Appendix 1-14) is generally more important towards the southeast. There are known "quarry" sites for each of these raw materials.

The secondary raw materials associated with the Hollandale Resource Region include Shell Rock Chert (Appendix 1-17) and Swan River Chert (Appendix 1-4). It is debatable whether Shell Rock Chert is better classified as a secondary or minor raw material; the limits on its use, however, may have more to do with its limited distribution and availability than with its intrinsic characteristics, so it is included as a secondary raw material. To date this Devonian chert has only been found at single source near the Minnesota-Iowa border and near the borders of Freeborn and Mower counties. Swan River Chert is present in the Des Moines lobe till in the western part of the Hollandale Region. There is little SRC use in the eastern part of the region, but the material becomes increasingly important to the west until it is a primary raw material in the adjacent Shetek Subregion of the South Agassiz Resource Region.

The minor raw materials associated with the Hollandale Resource Region include Maquoketa Chert, Tongue River Silica, quartz, Knife River Flint, Red River Chert, and materials more strongly associated with the West Superior Resource Region. Maquoketa Chert is a minor raw material because it is almost unworkable and almost never found at sites. Tongue River Silica (Appendix 1-21) is reported to be abundant in the old tills that comprise the central portion of the Hollandale region, but (unlike in other regions) it was apparently largely ignored as a toolstone. This is no doubt because better alternatives were almost always available in the form of the other regional raw materials (save Maquoketa Chert). It seem that quartz (Appendix 1-22) is present in the region, as is most parts of the state, although it also was not commonly used. Knife River Flint is present in the form of well-worn pebbles, at least in the western parts of the region, although they are not common and also are not suited to most reduction strategies. Red River Chert (Appendix 1-1) is present in the parts of the Region containing Des Moines lobe till, but the material was not much used. The West Superior Group materials (Appendix 1-5) should be, at a minimum, available in the northern part of the region where an area of Superior Lobe till is present. How much they were used, however, is not entirely clear at this point.

The most common exotic raw materials in this region are Burlington Chert (Appendix 1-30) and Hixton Group quartzites (Appendix 1-31). Knife River Flint (Appendix 1-32) occurs, but is normally rare, as is obsidian (Appendix 1-33). Other nonlocal raw materials include Maynes Creek Chert (Appendix 1-35) and Fusilinid Group (Appendix 1-34) cherts, and less commonly Moline Chert, other materials from Iowa, or rarely materials like Cobden Chert from more distant sources.

LITHIC RAW MATERIAL RESOURCE BASE

The following pages present the lithic raw materials that are often found at archaeological sites in Minnesota. This includes locally available raw materials as well as the more commonly-occurring nonlocal materials (including exotics). Most materials and groups are presented by the resource region where they occur, in order to complement the earlier definition and discussion of the regions. Next come the raw materials and groups that are not associated with a single region, including both multiregion materials and generically identified materials. These are followed by common exotics and other selected nonlocal raw materials and raw material groups.

The following pages include definition of proposed raw material groups, based on available information from both regional geology and raw material surveys. The groups should be regarded as provisional, and subject to verification or revision based on additional raw material survey or revised understanding of regional geology.

For reasons explained in Chapter 4, general flaking quality, size of the available raw material stock, and availability prove to be important raw material characteristics when it comes to understanding how raw materials were used. The following pages also summarize available information on these characteristics. For most raw material, the first paragraph reviews flaking quality, the second package size and the third abundance. The final paragraph briefly summarizes the information, for ease of reference. In the case of newly proposed groups, additional paragraphs may present further information.

South Agassiz Resource Region Materials

In addition to the following raw materials, the South Agassiz Resource Region also contains Tongue River Silica and materials from the Border Lakes Greenstone and Western River Gravels groups, plus numerous generically defined raw materials.

Swan River Chert

According to Campling (1980:293-294), the flaking quality of SRC ranges from "blocky through subconchoidal to conchoidal," with lighter-colored pieces exhibiting better flaking quality. He also calls SRC "a difficult material to work." Lee (1980:93 94) characterizes the fracture as "poorly conchoidal and generally blocky." Low (1996:167) notes that the material "is extremely hard to fracture" but that "Its workability is enhanced by heat treatment." In my own experience with breaking raw material samples (hardly a subtle affair compared to flintknapping), SRC is very tenacious. In plain speech, it's hard to break.

Campling (1980:292) documents a size range for SRC ranging from 64 mm to 256 mm for the samples he observed in Manitoba. Low (1995:83) describes SRC as ranging from pebble to cobble size in south-central Manitoba. Ahler (1977:139) notes that "Large boulders occur in the glacial deposits in the Missouri valley." Two SRC samples in the Fort Snelling comparative collection measure about 25 cm across. These and many other observed SRC samples occur as generally round to subround masses, although other shapes also occur. Grasby et al. (2002:277) note that SRC nodules from a primary geologic source are "elongated to rounded and vary from 5 to 75 cm in diameter." They further note that "the outer edges of samples commonly have vuggy zones, with small cavities that may or may not be infilled by later cement." This also describes the surface of many glacially-transported SRC clasts, suggesting that the clasts did not loose much of their dimension during glacial transport and thus might occur in a similar range of sizes as they do in primary context. In addition, this serves to reinforce the notion of just how tenacious this material can be.

Leonoff (1970:29), Campling (1980:292), and Low (1995:83) all comment on the abundance of SRC in parts of Saskatchewan and Manitoba. Grasby et al. (2002:275-276) and Low (1996) note that the highest concentrations occur in southwestern Manitoba, but that the overall distribution includes southeastern Alberta, southern Saskatchewan, and northern Montana, as well as parts of North Dakota and Minnesota. The material is well represented in the Fort Snelling comparative collection, indicating that it can also be common in

Minnesota. I have seen at least one location, a gravel pit along the Campbell beach ridge in western Roseau County, Minnesota, where cobbles and small boulders of SRC were abundant in piles of rocks screened out of the gravel.

In sum, SRC has variable flaking quality, but can generally be described as tenacious and difficult to work without heat treatment. The degree of improvement from heat treatment is not clear. Maximum documented size is around 25 cm in glacial clasts and 75 cm in primary-context nodules. The material is abundant in parts of its Canadian range, and common in at least parts of Minnesota and eastern North Dakota. (Note that SRC should be present in parts Iowa, and likely parts of South Dakota as well, although this is not presently documented.)

Red River Chert

The category Red River Chert subsumes two raw material types, Cathead Chert and Selkirk Chert (Bakken 1985).[5] The primary source areas for these materials are relatively close but they are geographically distinct. Cathead and Selkirk are identified separately by archaeologists in Manitoba, and it might be advisable for American archaeologists to also attempt separate identifications were comparative samples available. Given a certain amount of confusion already surrounding the identification of Red River Chert, however, this endeavor might best be left for the future.

There is not an abundance of information available on Red River Chert, and the following short summary includes information from personal observations. Gonsior (personal communication 8 July 2005) characterizes the flaking quality of RRC as being in the "better quality range." My observations generally confirm this. It is important to note, however, that many pieces of RRC break into small blocks along internal fractures or break unpredictably around fossils.

No information was found on the size of Red River Chert (i.e., Cathead and Selkirk cherts) in the primary sources near Winnipeg. In Beltrami County, Gonsior and Radford (2005:42) report "only small pebbles being available along the shoreline in reworked lake sediments," on the order of 2 to 5 cm. In northern Cass County and the surrounding area, Hohman-Caine and Goltz (1995b:9) report that "Small amounts of what is most likely Red River Chert appear to be present throughout most of this region (these appear to be absent

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5. Recent, ongoing research by Wendt (personal communication 2010) suggests in fact that the category Red River Chert may in fact subsume more than two chert types

northeast of the approximate Cass-Itasca County line). However, it most commonly occurs as small pebbles rarely much more than 2 or 3 centimeters in diameter." I have seen somewhat larger pieces, perhaps 10 to 12 cm, in the Tamarack Subregion, but they do not seem to be common.

Pebbles of Red River Chert are relatively common in the Des Moines lobe tills of the South Agassiz Resource Region. Larger pieces are occasionally found in the northern parts of that region. The material does not seem to fare well in glacial transport, however, so we might infer that larger pieces become increasingly rare to the south.

In sum, Red River Chert is a better-quality raw material, when pieces can be found that are free of flaws and fossils that cause it to break unpredictably or break into small blocks. It is most commonly available as pebbles of no more than 5 cm, with uncommon larger pieces (ca. 10-12 cm) probably limited to the northern part of the South Agassiz Region. As pebbles, however, it seems to be common throughout much of the South Agassiz Region.

Knife River Flint (local)

Understanding the distribution and use of KRF in the Upper Midwest requires distinguishing between primary and secondary source areas (sensu Gregg 1987a). These paragraphs deal with KRF in secondary source areas. A separate discussion below deals with the more restricted distribution of KRF in the primary source area.

The quality of this "local" KRF has not been well documented. My impression, however, is that the quality is generally lower for these redistributed pebbles than for the larger toolstone stock found in or closer to the primary source area. Many of the redistributed pebbles are tabular and tend to fracture along bedding planes. Some consist mostly of the light-colored, less-translucent form that might be seen on the exterior of larger, better-quality pieces. Others may have sustained cracks from weathering and transport, although this is less clear.

The size range is likewise not well documented. Morrow (1994:128) does note, however, that "secondarily deposited Knife River pieces seldom exceed 5 cm in maximum dimension" in Iowa, and Billeck et al. (1986:56) note that KRF "occurs in small pieces" in central Iowa. Again, my impression is that round pebbles seldom reach 5 cm in diameter. Tabular pieces may be longer than 5 cm, but are normally no thicker than 1 or maybe 2 cm. These numbers, however, should be verified.

Gregg (1987a) provides a good discussion of the distribution and characteristics of KRF beyond the primary source area. He notes its occurrence as far afield as northwestern Iowa (see also Anderson 1980:200) and central Iowa (see also Billeck et al. 1986:56). Pebbles of KRF also occur in some Des Moines lobe tills from east-central North Dakota and west-central to south-central Minnesota (Bakken 1985, 1993, plus unpublished observations).

In sum, the quality of local pebbles of KRF is usually poorer than the quality of material from the primary source area. Package size can generally be described as pebbles, either subrounded or tabular. Distribution in the study area includes areas with Des Moines lobe till, from east-central North Dakota and west-central Minnesota to central Iowa.

Silicified Wood

The silicified wood that is found in the glacial till of the Des Moines lobe is poorly known and minimally documented. The flaking quality appears to range from fairly good to marginal, although this is not tested. It often occurs as roughly tabular pieces that seldom exceed 5 cm in length, and it may also occurs as small, more rounded pebbles. It is not especially common.

West Superior Resource Region Materials

The West Superior Resource Region includes materials of diverse geologic origins, most with primary geologic sources within the region. The materials also have extensive distributions in glacial sediment. In addition to the materials listed below, in some parts of the region Tongue River Silica also occurs, along with numerous generically defined raw materials. Some parts of the West Superior Resource Region should also provide limited quantities of raw materials primarily associated with the South Agassiz Resource Region.

Fat Rock Quartz

Fat Rock Quartz is associated with the Little Falls formation in central Minnesota and is specifically distinguished from other varieties of quartz deriving from different sources. The name was suggested by a letter from C.H. Beaulieu (1902:122), transcribed in Brower's 1902 report on the quartz at Little Falls. In the letter, Beaulieu explains the meaning and origin of the Ojibwe name for Little Falls, and also notes that "the Ojibway people called white quartz winin wabik, or fat rock, from its resemblance to layers of fat in an animal." The material is newly (and incompletely) defined, but some relevant information is available. Harrison (personal communication 6 Oct 2006) calls this material "good quality." Wendt (personal communication 25 Aug 2007) goes further, calling Fat Rock "high quality quartz" and "the best quartz that I have seen across Wisconsin and Minnesota." Wendt (personal communication 23 October 2008) does caution, however, that Fat Rock is high quality compared to other quartz, more so than compared to the broader range of toolstone.

Wendt (personal communication 25 Aug 2007) notes "layers of vein quartz" in exposures of the Little Falls Formation near Blanchard Dam, and describes "pebble to melon size quartz cobbles." Gonsior (personal communication 12 Oct 2006) references a 200 to 300 lb boulder found by Brower near Fort Ripley and returned to the Minnesota Historical Society for curation.

Gonsior (personal communication 1 October 2006) notes that pebbles and cobbles of quartz are common in plowed fields near Little Falls to the juncture of the Crow Wing and Mississippi rivers, and especially at the confluence of the Nokassipi and Mississippi rivers. Wendt (personal communication 25 August 2007) notes abundant quartz cobbles and pebbles at a "picnic area on the east side of the Mississippi River at the end County Hwy 26 west of Royalton. There were numerous quartz cobbles and pebbles on the bank of the River." He further notes "many irregular quartz cobbles in the river" in the vicinity of Blanchard Dam (Wendt, personal communication 25 August 2007). Brower (1902:51, 53) notes that "the mineral can at present be quarried in considerable quantities below the dam at Little Falls, where it forms veins" and that "the present bed of the river is littered with slate and quartz detrital masses." In addition to the source at Little Falls, he notes a significant source at Pike Rapids south of Little Falls (Brower 1902:51, 55, 57), and a minor source on the Little Elk River north of Little Falls (Brower 1902:51, 61).

In sum, Fat Rock Quartz is an average quality material. It occurs often in pieces up to "melon size" (possibly 15 to 20 cm) and occasionally as larger pieces. It is common to locally abundant in the vicinity of Little Falls, Morrison County, but the full extent of distribution (especially glacial or fluvial) is not yet known.

Lake Superior Agate

Lake Superior Agate is probably best described as an average to marginal quality raw material. It sometimes breaks along the concentric rings that are a prominent feature of the material. Pieces that do not break along the rings, however, might have an acceptable flaking quality.

Julig et al. (1989:302) note that in the Thunder Bay area, "Agates commonly occur in pebble form." The agates I have seen are all pebbles, not exceeding 5 to 6 cm in diameter. Collectors assure me, however, that large agate – while rare – do occur. A collecting web site (http://www.dayooper.com/LSAgates.htm) displays a photo of a Lake Superior Agate that, based on a US quarter included in the photo, appears to be on the order of 60 cm across.

Lake Superior Agate appears to have a very wide distribution. Julig et al. (1989:298) document their occurrence near Thunder Bay, Wendt (personal communication 14 July 2004) in gravel pits north of the Twin Cities, and Gonsior (personal communication 22 November 2004) in the Grand Meadow area of southern Minnesota. Informal reports indicate that it can even be found into Nebraska and Kansas. The abundance of Lake Superior Agate over this larger area is, however, hard to assess.

In sum, Lake Superior Agate is commonly of average to marginal flaking quality. Most pieces are pebble size, although larger pieces occur rarely. The material can be found in a multistate region in the central United States, but there is little information on its abundance in this larger area.

Hudson Bay Lowland Chert

Harrison et al. (1995:21) note that pieces of HBLC have "high silica content, generally homogeneous texture and lack of a natural plane of cleavage," with the result that they are "characterized by good flaking properties and edge retention but have a tendency to potlid fracturing and outright shattering when subjected to heat." Observation of archaeological specimens confirms this and indicates that HBL is very fine grained, homogenous and isotropic, and appears to be of very good flaking quality.

Wendt (personal communication 23 March 2007), relaying information from Ross, reports pieces of HBL in the size range of pebbles to cobbles and less commonly "melon" size. This is in unspecified moraines north of Thunder Bay. Julig et al. (1989:302) report that "HBL (in the source region) is not uncommon as larger cobbles." Source region in this case refers to "glacial outwash and till which extend east and west of Lake Nipigon to the north of Thunder Bay."

The main (secondary) source of this material in the region appears to be moraines that are roughly 125 to 150 miles (ca. 200 to 240 km) north of the Minnesota-Ontario border (Julig et al. 1989:302; Rajnovich 1983:25), generally along an east-west line passing through Lac Seul and Lake Nipigon. Rajnovich (1983:25) also reports that cobbles may occur somewhat to the south along the English River. (Note that HBL is also found as far east as Quebec [Y. Codere, personal communication 15 January 1997].) There is little information on the relative abundance of HBL at these sources. Romano (personal communication 25 July 2005) notes that it is very rare in glacial sediment in the area of Pine County.

In sum, Hudson Bay Lowland Chert is a high-quality raw material that most commonly occurs as cobble-size pieces. The main source area is north of the immediate study area, although reports indicate that at least some HBLC can be found in the glacial sediments of northeastern Minnesota.

Animikie Group

The information for Animikie Group silicates is somewhat patchy and occasionally contradictory. Some materials or characteristics are well documented, others less so. Part of the problem, however, is terminology. Ongoing research by archaeologists in northeast Minnesota will address this.[6] For now, the following paragraphs summarize information that was located, supplemented by observation of raw material samples in reference collections.

Gunflint Silica. Romano notes that "Gunflint Silica is a variable material that grades from poor to excellent quality" (Romano 1994b:3). He further notes, however, that "It appears from collected examples that aboriginal stone workers were able to achieve the highest degree of skill using Gunflint Silica. I have never been able to get my hands on a piece of high grade Gunflint Silica, so I have no personal experience on its working characteristics" (Romano 1991c:4). Harrison et al., citing a source that could not be found, make these observations about pieces of GFS:

> Generally exhibiting one or more planes of cleavage, they have a tendency to block fracture that makes them less suited to the manufacture of large bifaces. The flaking properties of smaller, uniform pieces are excellent, however, and tools like small scrapers

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[6] See Klawiter and Mulholland 2009, and Mulholland and Klawiter 2009. These papers were published after the defense of this thesis, and thus are not further referenced.

> are frequently found on northern Minnesota sites, particularly on those dating from the later prehistoric period where the use of a bipolar technology allowed for the manufacture of smaller tool types out of smaller chunks of raw material (Newton and Englebert 1977). [Harrison et al. 1995:21]

Little information is available on package size, except the above observation by Harrison et al. that the best-quality pieces tend to be smaller. The Animikie Group silicates in general seem to have many fractures that cause larger pieces to break into numerous small pieces when they are struck (e.g., Romano 1991c:3). Presumably larger workable pieces could be had from bedrock sources, although this assertion requires further research.

Romano (1991c:4) reports that "Historic literature has linked the source of this material to Gunflint Lake on the eastern end of the Border Lakes. Last summer, your editor and I collected 'gunflint rock' from the shore of Gunflint Lake. This rock had ample sampling of Gunflint Silica but by no means was it of the quality found in many artifacts. We also did not find any signs of quarrying there." Romano (1994b:3-4) further reports "Sufficient unworked chunks of Gunflint Silica (as well as Jasper Taconite and Kakabeca Chert) found in road cuts and new plowing attested to its local availability" in the Pine City (Pine County) area, but further notes that "I have never found a piece that was workable because of extreme jointing." Hamilton (1996:75) posits a till source in the vicinity of the McLusky site in the Thunder Bay region.

In sum, Gunflint Silica can be of very good flaking quality, although the best quality pieces may be relatively small. Good bedrock sources remain elusive, but the material appears to be widely available (possibly as pebbles and cobbles) in glacial till.

Biwabik Silica. There is comparatively little information on Biwabik Silica. This is essentially a metamorphosed form of Gunflint Silica, and some of the observations that apply to Gunflint Silica may also apply to Biwabik Silica.

Romano (1994b:4) reports that samples from a Hibbing mine were flakeable but not especially easy to flake, although it was possible to flute an experimental Clovis point of the material. No information was found on package size for Biwabik Silica. Regarding potential sources, Romano (personal communication 8 September 05) that "Biwabic Silica is not as abundant in the till" as Jasper Taconite, Gunflint Silica or Kakabeka Chert in the vicinity of Pine City (Pine County). He further notes that

> Gruner, 1946, reports that early geologists who, following raging forest fires creating better visibility, made surveys in the area and recorded several outcroppings of the Lower Cherty Member. One of these was at the "Virginia Horn" which is a horn-like projection of the Mesabi Range pointing in a northeastern direction near Virginia Minnesota.

> Hibbing Taconite Company geologist, Henry Djerlev... wrote that he would suggest that the Biwabik Silica may have been found in the glacial float... on, or near, the Mesabi... probably to the south." [Romano 1994c:6]

In sum, we have limited information on the flaking quality, package size and distribution of Biwabik Silica. Pending the availability of more information, however, we might consider whether the general information for Gunflint Silica can be applied to Biwabik Silica, except for a more southerly distribution and a thinner distribution in glacial sediment.

Jasper Taconite. Gonsior (personal communication 14 July 2004) and Wendt (personal communication 14 July 2004) agree that Jasper Taconite is a highly flakeable material, if you can find a good piece. Julig et al. (1989:296), without commenting directly on flaking quality, note that beds of the material "are flawed by numerous cleavage planes. ... The many cleavage planes... result in numerous manufacturing failures in the process of lithic reduction." Harrison et al. (1995:21), quoting a personal communication, caution us that "The flaking properties of this material vary considerably, and experiments with heat treatment suggest that the procedure makes little difference to texture and workability (Ross, personal communication 1984)." Romano (1991c:3) notes that "Taconite Jasper 'works' a whole lot better than Knife Lake Siltstone. Its conchoidal fracture shows that the inclusions fracture less smoothly than the matrix and it produces a faintly 'pebbly' surface."

Julig et al. (1989:296) report that in the vicinity of Thunder Bay, "Individual bands of taconite are commonly 10 to 30 cm in thickness, with thicker beds observed in the vicinity of the Cummins site" (a Paleoindian quarry and workshop covering several hundred acres). Morrow and Behm (1985:9) report "Tabular slabs and angular blocks 10 cm. and more in diameter," although it is not clear whether this estimate pertains to pieces from bedrock in the north, or to glacial sources in Wisconsin. Wendt (personal communication 29 March 2007) reports finding "four hunks that varied from 1 to 5 pounds," which might generally be correlated with a size range from large pebble to cobble. He also notes that these pieces fractured along internal cracks into chunks no more than 3 inches (7-8 cm) in maximum dimension. The Animikie Group silicates in general seem to have many fractures that cause larger pieces to break into numerous small pieces when they are struck (e.g., Romano 1991b:4, 1991c:3). Presumably larger workable pieces could be had from bedrock sources, although this assertion requires further research.

Fox (1975:32, 1980), Hinshelwood and Webber (1987:27), and Julig et al. (1989:294-297) all report on bedrock outcrop sources in the vicinity of Thunder Bay. Steinbring (1974:67-68) relays a report from the older geological literature of "Another aboriginal quarry of jaspillite... discovered in St. Louis County, Minnesota, by George R. Stuntz, a government land surveyor during the mid-1800s. He reported it and other archaeological observations in two papers, published by the Minnesota Academy of Natural Sciences (1884, 1885), giving detailed location data...." Several parties offer documentation of the very widespread occurrence of Jasper Taconite in glacial sediment. This distribution includes beach cobbles, river gravels in glacial sediment in northwestern Ontario in the vicinity of Thunder Bay (Julig et al. 1989:296). Romano reports its occurrence in Pine County (personal communication 8 September 2005), and that "It is also frequently found in the glacial till" (Romano 1991c:3). Wendt (personal communication 14 July 2004) notes that Jasper Taconite is "very common in glacial till" exposed in gravel pits north of the Twin Cities. Gonsior (1996:10) reports finding the material in "glacial till deposits on top of bluffs along the Mississippi River near Cochrane, Wisconsin, where the underlying bedrock is the Prairie du Chien Formation. Apparently this is a secondary deposit, since the till contains cobbles and boulders of Cochrane Chert, Alma Quartzite, and a variety of material from the Lake Superior region including Animikie Silicates (i.e., Jasper Taconite)." Morrow (1994:119) even reports that "jasper taconite... commonly found in glacial till across Iowa, was very rarely used for chipped stone tool production in the state."[7]

In sum, Jasper Taconite varies in flaking quality, but the best pieces are very flakeable. Package size at bedrock sources could be as great as 30 cm, although most of the material probably occurs as smaller pieces. Package size in secondary, glacial sources may be on the order of 8 to 10 cm for some distance south of the primary (bedrock) source area, and progressively smaller to the south. Primary sources are limited to outcrops of iron-formation in parts of northeastern Minnesota and northwestern Ontario, to the west of Lake Superior's North Shore. Secondary deposits are widespread, and cover an area from the primary sources in the north, through central Minnesota and west-central Wisconsin, and into Iowa.

Kakabeka Chert. Romano (personal communication 25 July 2005) reports that Kakabeka Chert "knaps very well." As with all of the Animikie Group silicates, it can be difficult to find a piece that does not break into small blocks when struck (Romano 1991b:4). Romano (1991b:4) also reports that he saw no improvement in flaking quality from heat treatment.

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[7] Note that a report of Jasper Taconite in northwestern Minnesota (Bakken 1985, 1997) is probably wrong. These pieces are more likely kipalus (see Prest et al. 2000).

Romano (personal communication 25 July 2005) also reports that the material "occurs in some surprisingly large chunks," but does not specify a size range.

According to Harrison et al. (1995:21), the only known outcrop of the material is at Kakabeka Falls near Thunder Bay. Romano (personal communication 25 July 2005) reports that it is "very abundant in the till" in Pine County.

In sum, Kakabeka Chert is a good quality material, although it can be challenging to find a piece that does not break into small chunks along internal seams and fractures. Package size could not be determined beyond "large." Primary geologic sources are limited to a single outcrop near Thunder Bay, but the material appears to be relatively common in some glacial sediments.

Pipestone Resource Region Materials

At this point there is little information on the Pipestone Resource Region and its native raw materials, except for the more widespread Tongue River Silica. We might assume that there are a number of raw materials, but at this point we only have information on Gulseth Silica. Additional research is needed to better define this material, and additional raw material survey is needed to determine what other raw materials might be added to this group.

Gulseth Silica

This material was initially recognized in lithic assemblages from a survey in Rock and Pipestone counties (Skaar et al. 1994), when an initial description was provided. Little more has been learned about the material since that time. It is not clear whether Gulseth might be identified by a different name (or names) in the archaeological literature for South Dakota or even North Dakota. There has been some effort to find such associations and hopefully even identify a primary geologic source, but progress has been slow to this point.

Hollandale Resource Region Materials

The Hollandale Resource Region includes a number of raw materials that are principally available at or near their primary geologic contexts. There is probably also some glacial and fluvial redistribution of these materials, but so far that does not seem to be as important a raw material source. In addition to the raw materials listed below, the region also contains

Tongue River Silica, materials from the Sioux Quartzite and Western River Gravels groups, and numerous generically defined raw materials. Materials from the Border Lakes Greenstone Group may be present, but they are probably not abundant. Materials associated with the West Superior Resource Region are present in the western and northern parts of the region, but are relatively less important here than in the South Agassiz region; note also that the importance of these materials decreases from northwest to southeast across the Hollandale region. Other materials, may be locally available from erosional exposures of otherwise buried glacial sediment. This possibility should be regarded as speculative, however, pending field survey directed at finding such sources.

Prairie du Chien Chert

Withrow provides useful and detailed observations on the flaking quality of this material:

> In their natural state, Prairie du Chien Group cherts can be flaked with difficulty. The chert is rather tenacious and is frequently ridden with internal cracks and flaws. These obstructions may be eliminated if the materials were procured in a less weathered condition, perhaps through quarrying. In many instances, however, textural changes and internal pores of quartz crystal would remain significant obstacles. In addition, some oolitic varieties may be too coarse and grainy to be worked on a fine scale. If pieces of sufficient size free of internal cracks or inclusions are obtained, the chert would certainly be suitable for knapping. Heat-treating serves to enhance the flaking properties of both non oolitic and oolitic varieties. They become more brittle, but remain quite durable. Flakes are removed easily and generally have cleaner, sharp edges. [Withrow 1983:49]

Gonsior (1992a:5) concurs, stating that "Both the Oneota and Shakopee varieties of Prairie du Chien chert are moderate quality cherts that can be difficult to knap in their natural state. Heat treating is clearly a prerequisite for successful flintknapping."

Regarding available size, Gonsior (1992a:4) notes that "Oolitic cobbles commonly... occur in grotesque shapes with large boulders common in some areas." Morrow (1994:118) notes "nodules and nodular beds up to 30 cm thick," while Morrow and Behm (1985:14) note that the material "Occurs in isolated nodules and relatively continuous beds between 5 and 20 cm. or more in thickness." Withrow notes that in the Oneota Formation, "The chert generally occurs in layers, lenses, and spherically shaped nodules. Layers or lenses of chert may be as much as 5 to 6 inches thick while isolated spherical bodies may range from 2 to 20 inches in diameter and up to a foot in thickness" (Withrow 1983:45), while in the Shakopee Formation it "occurs much more sparsely and usually appears in the form of scattered small nodules and thin lenses" (Withrow 1983:47).

Regarding general availability in Minnesota, Gonsior provides useful and specific information:

> Prairie du Chien chert is the most common chert in southeastern Minnesota and can easily be found in streambeds, roadcuts, and as lag deposits especially along the loess... covered edge of the Mississippi River Valley in Wabasha and Winona counties. Secondary deposits of chert from the Shakopee Member are extremely plentiful in the Mankato and Le Sueur area along the Watonwan, Blue Earth, Le Sueur and Minnesota rivers. Lag deposits have also been identified on uplands west of the Blue Earth River." [Gonsior 1992a:4]

For Iowa, Morrow notes that "Oolitic cherts initially derived from these formations are frequently encountered in glacial gravels throughout much of northern and eastern Iowa" (Morrow 1994:118).

In sum, Prairie du Chien Chert is an average-quality material that occurs in pieces as large as cobbles and boulders. Availability varies across its range, but in some areas it is abundant. It can be found in both primary and glacial contexts, but the flaking quality of material from the former is probably better.

Cedar Valley Chert

It is important to note that a suite of related raw materials sharing a common origin is distributed across parts of southeastern Minnesota and west-central Wisconsin. These include Cedar Valley, Cochrane and Chocolate cherts, and probably other materials. The origin of these materials has been explained, but until the related nomenclature has been clarified[8] the following discussion focuses on the Minnesota sources and Cedar Valley material.

In the initial description of Cedar Valley Chert, Ready (1981) notes a "mixture of both high quality and extremely unworkable grades of chert." Gonsior provides further good, detailed observations:

> Textural differences vary from chalcedony like to medium quality chert to poor quality chert within the same nodule.... The opaque variety is an excellent material for flintknapping. It is a hard material to work with in its natural state, but is vastly improved by heat treating. Heat treating in the 400 to 500 degree Fahrenheit range is sufficient.... With heat treatment, a more subtle approach is necessary for flaking and edge preparation such as would be used with obsidian. The translucent variety requires some experience since the textural differences are a problem. Flakes easily travel

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[8] It may be that definition of a "Root River Group" would be one potential way to resolve the difficulties in nomenclature (cf. Moffat 1996; cf. Boszhardt 1998a).

> through the exterior chalcedonic layer but do not travel well through the coarser interior and often hinge. The grainy translucent variety can be percussion flaked, but is very difficult to pressure flake." [Gonsior 1992d:5]

Gonsior (1996:7) also adds another useful observation: "Cedar Valley Chert (CVC) is a high-quality silicate occurring in the Upper Mississippi River region. This region is characterized as having mediocre quality cherts."

Ready (1981) describes "irregular, somewhat lenticular 'slabs' up to roughly 30 cm. at their greatest dimension." Gonsior (1992d:5) does not provide metric information but notes that "Both the opaque and translucent varieties are found at the Hadland Site along the South Branch of the Root River in Fillmore County as nodules or slabs, often cemented together into large boulders."

Gonsior notes that

> In southeastern Minnesota, glacial till covers most of the western portion of the Devonian age bedrock with a thick mantle of till over 100 meters deep. Only the eastern portion is within a karst topography landscape.... There is, however, a thin mantle of pre-Wisconsin till. This glacial residuum is comprised largely of silicates, including cobbles of CVC. Typically, the primary and secondary chert deposits are buried by 1-10 meters of loess.... Therefore, acquisition of this material is limited to landforms where the loess is shallow or eroded. [Gonsior 1996:10]

He further describes geomorphic processes that may have contributed to exposure of CVC. In addition, Gonsior (1996:9) notes that there are "five known aboriginal procurement sites... Chally/Turbenson site (21FL71), the Mundfrom/Till site (21FL73), the Hadland site (21FL60), the Ready site (21MW15) and the Prohaska site (21FL19), which are located along a 20 kilometer northwest to-southeast transect in Fillmore and Mower counties." The published descriptions do not provide much information on the abundance of the material at such sites, but my own observation is that clasts of the material are abundant there.

In sum, Cedar Valley Chert is a very good quality material, especially when it has been heat treated. It occurs in pieces as large as 30 cm in maximum dimension, and possibly larger. Cedar Valley itself is available and locally abundant in a restricted area in Mower and Fillmore counties in southeastern Minnesota, while allied materials are available in parts of west-central Wisconsin. These related materials may be similar to Cedar Valley in flaking quality and package size, although this should be investigated more closely.

Galena Chert

There is some apparent disagreement about the flaking quality of Galena Chert. According to Withrow (1983:53), the material is "fine-grained, homogenous, relatively free of crystalline pores or other inclusions and [is] well-suited to stone tool manufacture. Some specimens fracture quite well in their natural or untreated state. They fracture leaving a sharp edge and appear to be very durable. They respond favorably to heat-treatment." In contrast, Stoltman et al. (1984:202) judge that Galena is "not of notably high quality." However, in their assessment of flaking quality, Stoltman et al. (1984:200) include the observation that "Flaws and weathering fractures are common, so that blocky fragments abound." Withrow (1983:53-54) judges flaking quality apart from this, noting that "Any limitations to their use as a suitable raw material for stone tool manufacture would seem to be only that of procuring workable specimens in sizes appropriate for reduction or obtaining unweathered material free from internal flaws." Gonsior's (1992b:5) comments are helpful in resolving this: "Galena chert is a good material for flintknapping, however it is considerably easier to knap after heat treating."

Morrow and Behm note that "Both isolated nodules and continuous nodular beds are known; nodules normally around 10 cm. in thickness, but sometimes up to 20 cm thick" (Morrow and Behm 1985:15; cf. Morrow 1994:119). Withrow (1983:51-2) says that "Galena Group chert occurs most commonly as smooth-surfaced flattened nodules one to three inches thick, but may occur locally up to five or six inches thick. The nodules vary in size and shape, usually appearing as rounded or elliptical masses as much as one foot across, but occasionally they take irregular forms." Gonsior (1992b:4) reports, based on his study of Galena Chert availability in Fillmore County, southeastern Minnesota, that "Galena chert occurs as irregular shaped nodules varying in thickness from one inch to one foot across. It is located in veins reportedly up to 10 feet in thickness. The thickest vein I have examined was a foot thick and was comprised of densely packed chert nodules." He also notes that "Finding nodules large enough for flintknapping can be difficult since most of the nodules I examined at lag deposits in Fillmore County were small and blocky" (Gonsior 1992b:5).

Regarding abundance and availability, Withrow (1983:52, for Wisconsin) notes that "In places where chert is abundant, nodules may form a continuous bed of chert that can be traced some distance." Stoltman et al. (1984:200, for Wisconsin) describe lag deposits of chert covered by Pleistocene loess, and early Holocene "erosion of headwater stream channels [which] would have exposed veritable chert mines along the flanks of those upland ridges underlain by the 'Cherty Unit' of the Galena Formation." Speaking of a site locations in Fillmore County of southeastern Minnesota, Myster (1996:18) notes that "Galena Chert was available as lag deposits at the eroded margins of the river valley walls." Gonsior (1992b:4) reports that "Galena chert can be extremely plentiful in loess covered lag deposits in Fillmore County, especially where veins are evident. These surface lag deposits can be followed for miles and were extensively utilized by American Indians."

In sum, Galena has good flaking quality in pieces that are free of cracks and other flaws. Heat treatment improves its working characteristics. Nodules are typically 10 to 12 cm thick, occasionally as much as 20 cm thick, and sometimes as much as 30 cm across. In the locations where it occurs, supplies of this material can be very abundant, and exposures can stretch for miles.

Grand Meadow Chert

Gonsior provides a good description of the flaking qualities of this raw material:

> Grand Meadow chert is an excellent lithic material for flintknapping because of its lack of inclusions and faults, and surprising strength which allows some error in flintknapping. It is unquestionably the highest quality chert found in Minnesota. Its workability is improved, especially for pressure flaking, by heat treating in the 400 to 500 Fahrenheit range, however it is unnecessary for percussion flaking" [Gonsior 1992c:5]

Withrow (1983:58-59) basically agrees, noting that at that time GMC "remains untested. Intuitively, the Grand Meadow chert shares a number of characteristics which suggest that it is well-suited to stone tool manufacture, even in its natural state. It is remarkably homogeneous and relatively free of impurities." Trow (1981:102) concurs, saying simply that the material is "high-quality."

Gonsior (1992c:5) notes that GMC "is found as cylindrical, elongated, and rounded nodules up to one foot in length." Trow notes (1981:102) "whole nodules up to 25 cm thick." Morrow and Behm (1985:18) describe "Oblong to cylindrical nodules around 10 to 15 cm. in diameter." Wendt (personal communication 26 July 2005) describes "5 [inch] dinosaur egg shaped nodules... large (3" dia.) worm trail like tubes... small nodules down to walnut size."

Comments relating to the abundance of GMC center on descriptions of the quarries. Trow (1981:102) describes "Scores of large pits, up to 3 m deep and 5 m in diameter," and notes that "Evidence of quarrying and initial flaking of the stone covers an area of at least 68 ha (170 acres). Gonsior (1992c:5) notes that the "chert nodules are in a dense layer a meter below the surface." Wendt (personal communication 26 July 2005) observed "dense concentration of Grand Meadow chert" in utility trenches 6 to 8 ft deep, 1 mi east of the quarry site. Gonsior (1992c:5) further notes that "Secondary deposits have also been identified in gravel pits along the south branch of the Root River in Fillmore County."

In sum, Grand Meadow Chert is a high-quality material that is made better by heat treatment. It commonly occurs in pieces measuring about 10 to 12 cm, and sometimes in pieces up to 25 or 30 cm. It is especially abundant in a layer 1 to 2 m below the surface in and near the quarries at the town of Grand Meadow in Mower County, and secondary sources also occur.

Shell Rock Chert

Olmanson et al. (1994:36) and Bakken (1995c:3) describe Shell Rock Chert as "relatively homogeneous, and the fracture conchoidal. Flaking quality may generally be described as good."

The material is described as occurring as "pebbles to pieces less than 20 cm in maximum dimension" (Olmanson et al. 1994:37). This description was based on samples reposited in the Fort Snelling raw material reference collection. Re-examination of these samples suggest the need for a clarification: The largest sample does measure about 20 cm in length, but this is larger than most of the pieces. The typical size is closer to 10 to 12 cm.

The distribution of this material is very limited. The only known source is the Sherbun's Creek site (21MW18; Olmanson et al. 1994) in southwestern Mower County; the material is relatively abundant at the site. The prevalence of Shell Creek Chert at sites drops off quickly away from this vicinity, however (Bakken 1995c). The geology suggests that the material would be found in glacial till to the south and into adjacent parts of Iowa, but such a distribution has not been documented.

In sum, Shell Rock Chert is a reasonably good quality material. It commonly occurs in pieces about 10 to 12 cm in diameter. It is relatively abundant only in a very small source area, and the overall importance of the material is quite limited.

Maquoketa Chert

According to Gonsior (1992b:6), Maquoketa Chert is "a low grade material that is appropriately termed tough for flintknapping. The small amount of experimental flintknapping that I have conducted is characterized by frustration. When reducing nodules or bifaces, the bands separate. Heat treating to 500 degrees Fahrenheit improves the workability, but the structural deficiencies remain."

Gonsior (1992b:5) further notes that it occurs as "elongated nodules of up to a foot in diameter, although most are smaller and are commonly in the 3 to 6 inch range."

He also says that "Apparently the only known surface exposures in Minnesota are found in Fillmore County" (Gonsior 1992b:6).

In sum, Maquoketa Chert is a submarginal material, only minimally improved by heat treatment. Nodules are commonly 10 to 15 cm across, although they can reach 30 cm. Known exposures of the material are limited to Fillmore County. It should also be noted that although this is a minor raw material, it does occur at sites (albeit rarely), and thus should be accounted for in the model of raw material use.

Tongue River Silica

It appears that Tongue River Silica was first carried eastward from a primary source area in North Dakota. The location of the original, primary source is not clear, although Goltz (2002:7) has proposed

> an early (as yet unrecognized by geologists) ice advance from the northwest which flowed through the Souris River Valley south of the Turtle Mountains in North Dakota and into Central Minnesota. This would have brought reddish colored drift. There is a prominent “valley” that traverses southwest of Duck, Riding, Porcupine Mountains in Canada indicating the route of this advance. This would cross the Tertiary deposits in western North Dakota which are the source of the TRS. TRS specimens collected from the south slopes of the Turtle Mountains are identical to Minnesota specimens, except for less rounding from long distance transport.

This scenario seems plausible, and deserves careful consideration. An early ice advance accounts for the abundance of TRS in the old tills of the Pipestone Resource Region and along the eastern fringes of the Des Moines lobe tills in southeastern Minnesota and northeastern Iowa. It explains how the later Des Moines lobe could have incorporated these earlier tills and spread a thinner distribution of TRS throughout the southern reaches of the

South Agassiz Resource Region (excluding northwestern Minnesota, possibly some of northeastern North Dakota, and points north). It can also explain the abundance of TRS in Wadena lobe tills, if this extension of the Rainy lobe incorporated material from some earlier ice advance (cf. Bakken 2002a).

It is possible that Tongue River Silica, pebbles of "local" Knife River Flint, and pebbles of an unnamed silicified wood share a vector of transport into Minnesota. The mechanism for the distribution and mingling of these materials is speculative, however, since the association is based on somewhat circumstantial evidence. First, KRF and silicified wood originate from the west, in the same general area as TRS. Second, they generally occur as subangular clasts, well worn (cf. Gregg 1987) but not reduced to rounded pebbles like the clasts in the Western River Gravels Group, suggesting shorter transport for the former than the latter. Finally, they seem to occur in the same areas as TRS, although this point clearly needs to be examined more closely.

On a final note, it is important to note that this entire discussion pertains only to the yellow-red variety of Tongue River Silica, and not the fine or coarse grey varieties. Tongue River Silica is usually described in terms of three varieties: yellow-red, fine grey and coarse grey (e.g., Ahler 1977). These have somewhat different flaking qualities. Their distributions do overlap, but the grey material has a more western distribution while the yellow material extends farther to the east. The relationship between the varieties is not easy to sort out based on available information, in part because reports do not always specify whether they concern yellow or grey varieties. This thesis essentially treats the yellow and grey varieties as separate materials. Grey TRS is a minor material at Minnesota sites, and will seldom be discussed. Any mentions of TRS should be taken to mean the yellow-red material unless grey TRS is specified.

In terms of flaking quality, Anderson (1978:149) calls TRS "marginally suitable. In its natural state, TRS is nearly impossible to work." Ahler (1977:139) notes that this material is "distinctively sub-conchoidal in fracture." Porter (1962:268) says that "This material is extremely tough and resists weathering. Pieces found resting upon the Pierre shale west of Mobridge were so tough that the writer was unable to secure samples with a standard geologist's rock hammer." Note, however, that Porter seems to refer to both the yellow and grey and materials. Anderson (1978) describes how heat treatment improves the flaking quality of TRS and renders it at least minimally flakeable.

Morrow (1994:128) notes that "Cobbles of Tongue River silica up to 40 cm in diameter are available from these secondary sources" in western Iowa. Ahler (1977:139) notes that

TRS can "occur as boulders in local glacial outwash or till deposits within the Missouri River valley" in South Dakota. Gonsior (personal communication 26 December 2002, 23 October 2008) observed a TRS boulder on the order of a meter across in the old till in western Fillmore or eastern Mower County. Goltz (personal communication 28 Aug 1996) reports the presence of smaller but still sizeable cobbles of TRS in parts of central to north-central Minnesota. Pieces collected by Bakken (1985) were smaller, ranging from pebbles to small cobbles. This probably reflects incorporation of TRS from older tills, with smaller sizes resulting from the addition of another vector of glacial transport.

Goltz (2002) reports that a "Cass-Wadena Ottertail County 'hot spot' really shows in the glacial drift, especially in central Cass County" in central Minnesota. Gonsior (personal communication 26 Dec 2002}reports abundant TRS in "the old till in far western Fillmore and eastern Mower County." Morrow (1983, 1984b:34) reports that TRS is "abundant in cobble form in glacial gravels throughout western Iowa and also occurs in river gravels in eastern Iowa." Anderson (1978:149) notes that "Naturally occurring Tongue River cobbles are distributed rather generally in glacial gravels of the region" and that they are "abundant." Bakken (1985) documents the presence of TRS in Des Moines lobe sediment, although the materials is less abundant in this context. This probably reflects incorporation and dilution of older tills containing TRS.

In sum, Tongue River Silica is a marginal quality that is made workable by heat treatment. In older tills, and possibly in areas nearer the primary geologic source, TRS is especially abundant and occurs in sizes up to large boulders. In younger tills that incorporated and diluted the older tills, TRS is less common and occurs in sizes that probably do not exceed mid-sized cobbles.

Border Lakes Greenstone Group

The Border Lakes Greenstone Group includes three specifically-defined raw materials. These are Lake of the Woods Siltstone (aka "Chert "), Lake of the Woods Rhyolite, and Knife Lake Siltstone. These come from greenstone belts that crop out in an area beginning near the north end of Lake of the Woods and extending to the east and northeast (see Ojakangas and Matsch 1982:26). Other raw materials may also come from these greenstone belts. If this is the case, they would also belong in the BLG Group. There is presently little information available on such other materials, however, and if they are present in the samples from raw material surveys they remain unrecognized. In addition they do not seem to constitute a noticeable presence in regional lithic assemblages. Ongoing research on lithic raw materials in eastern Manitoba and northwestern Ontario will hopefully clarify the picture in the future.

There are two important points of ambiguity in the definitions of the Border Lakes Greenstone Group and its constituent raw materials. First, Lake of the Woods "Chert" and Knife Lake Siltstone are either the same material or closely related materials (cf. Nelson 1992, 2003; Saini-Eidukat and Michlovic 2003). The appellation "chert" in Lake of the Woods Chert is actually incorrect. It is, however, established by long usage. I somewhat reluctantly recommend a change in the name (a practice I generally do not recommend) to Lake of the Woods Siltstone since it corrects a significant error in nomenclature, and better reflects the relationship between Knife Lake Siltstone and Lake of the Woods Siltstone. In the remainder of this thesis, I will use the revised name.

Second, there are still problems with distinguishing Lake of the Woods Siltstone, Lake of the Woods Rhyolite, and Knife Lake Siltstone. In some cases the distinction is clear, in other cases not at all. In part this relates, of course, to the fact that Lake of the Woods Siltstone and Knife Lake Siltstone are the same or related raw materials. In part it also relates, however, to the fact that there is also a genetic relationship between the rhyolite and the siltstones. Erosion of rhyolite provided the sediment that was consolidated into siltstone (cf. Nelson 1992, 2003; Ojakangas 1972a, 1972b). Thus although the stones are of different origin – igneous extrusive versus sedimentary – they share such characteristics as mineral composition and color and an essential resemblance to each other. One source (Bakken 1997) recommended identification based on translucency: moderately to slightly translucent pieces should be identified as rhyolite, while opaque pieces should be identified as "chert" or siltstone. This distinction has not proven satisfactory, however, and the reliable identification of these raw materials needs to be carefully re-examined.

The Border Lakes Greenstone Group is not associated with a particular raw material resource region. The constituent materials are found in both the South Agassiz and West Superior Resource Regions.

There is some difficulty in sorting out information on flaking quality, package size and availability of the Lake of the Woods members of the Border Lakes Greenstone Group raw materials. In part this is because of inconsistent terminology (reflected in the quotations below), and in part because of the difficulties in clearly separating the materials. This does not need to be analytically crippling, however, since for immediate purposes the materials can be treated as coming from a single source. Given such factors, it seems advisable for now to discuss the two materials in tandem. Obviously it is desirable to sort our information on the individual raw materials at some point. Knife Lake Siltstone is discussed separately, except for some information on overall distribution of BLG Group materials.

Knife Lake Siltstone

There is variation in the quality, size and abundance of KLS between the bedrock quarries to the north and glacial till sources to the south. Therefore both of these sources will be treated in the description. Nelson (2003:108) notes that "The highest quality material that we located at the quarries on Knife Lake... is extremely fine grained, homogeneous and high in silica." Goltz (personal communication 4 September 1996) reports finding "very high quality dark gray siltstone" at locations in Cass County. Regarding KLS from till-relates sources, however, Malik and Bakken (1999:158) note that "none of the siltstone from Bradbury Brook seems to be of especially good quality. Many pieces of siltstone exhibit coarse, grainy areas that, combined with bedding planes, cause the siltstone to fracture in an unpredictable fashion." Harrison et al. (1995:20) note that the presumably till-derived KLS from Reservoir Lakes sites is "microcrystalline and siliceous enough to have a conchoidal fracture, i.e., good to very good flaking properties," but further describe it as "quite variable in terms of silica content, grain and homogeneity/flakeability, ranging from more coarse-grained laminated slate-like forms with parallel, planar cleavage, to fine grained, highly siliceous, almost chert-like varieties." Romano (1991a:4) notes that "the 'run-of-the-mill' material is a heart breaker to work" and that "it does not yield well to pressure flaking."

Nelson (2003:108) says that at the quarries KLS occurs as "boulders, cobbles and fragments. At some of the quarry areas the fine grained material is found in bands over a metre wide. Consequently, the size of artifacts made from KLS from the quarries isn't restricted by the material." The size of KLS clasts in glacial sediment is not well documented. If memory serves, however, pieces in rock piles at the Bradbury Brook site were commonly around 25 cm (1 ft) in diameter although larger pieces may have been present. Goltz (personal communication 30 July 2008) notes that the largest decent-quality KLS boulder he had seen in till sources was about 30 cm, and that the "higher grade, almost chert-like" KLS occurred in smaller pieces. He also notes that bigger boulders may look like KLS, but "you really need to break them open to be sure. Typically, what looks like decent siltstone on the smooth outside is actually quite grainy and not really knappable on the inside."

Wendt (personal communication 31 July 2008) notes "large areas of KLS on the Minnesota side of Knife Lake at the southwestern end" and that "At a few spots there were outcrops of high grade KLS... There was no evidence of it having been a prehistoric quarry site." L. Johnson (personal communication to Wendt, 31 July 2008) notes, however, that Forest Service survey has documented numerous quarry locations on the American site of Knife Lake.[9] Harrison et al. (1995:20) note that "siltstones are also frequently found as cobbles in glacial drift deposits." KLS cobbles were common in rock piles at the edge of the field containing the Bradbury Brook site, in Mille Lacs County a few miles south of Mille Lacs Lake. Hohman-Caine and Goltz (1995b:10) report that "Some very high quality siltstone was observed in the region, particularly in the area south of the western end of Leech Lake... As a whole, however, even lower quality siltstone exhibited spotty occurrence, often being completely absent from study sites."

Lake of the Woods Siltstone and Lake of the Woods Rhyolite

Rajnovich (1983:15) notes that "Local rhyolite, also available as beach cobbles and often within the same cobble as chert, has a low frequency at this site, perhaps because its grainy texture and internal faults made it unattractive for most tool types." Dillon Carr (personal communication 19 January 2006) notes that there is "quite a variable range (both in terms of quality and macroscopic features)" for the Lake of the Woods materials. This kind of variability can be seen in reference samples of Lake of the Woods Rhyolite in particular. A single clast might vary from fine to coarse grained. In terms of overall quality observed in artifacts, it seems that the siltstone *can* sometimes be very fine grained, homogenous and flakeable, to a degree not seen in the rhyolite. There is probably substantial overlap, however. Carr (personal communication 19 January 2006) also notes, for example, "one or two high quality outcrops on or immediately near Lake of the Woods."

Halverson (1988:11) reports a site on Stephen Lake (immediately east of Lake of the Woods in northwestern Ontario) where "very large veins of local chert" had been quarried. This site also provided "large cobbles of local chert." Rajnovich (1983:15) describes "Local rhyolite, also available as beach cobbles." One sample in the Fort Snelling reference collection, collected from till sources in western Minnesota, measures about 25 cm in maximum dimension. This establishes a minimum package size for material from outcrops,

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[9] See Clayton and Hoffman (2009), published after the final defense of this thesis.

since glacial transport can only reduce the size of clasts. While the 25 cm sample also establishes that boulder-sized pieces are available from glacial sediment, the more common size is probably in the range of 10 to 15 cm in the north part of the South Agassiz Region, and smaller to the south.

Border Lakes Greenstone Group Distribution

The extent of the primary resource area is not clear, but we can establish some approximate limits. These materials come from a series of greenstone belts that extend from northwestern Minnesota and eastern Manitoba to the east-northeast across northwestern Ontario (see Ojakangas and Matsch 1982:26). The westernmost end of this greenstone belt is buried, and it first crops out near Lake of the Woods in southeastern Manitoba and northwestern Ontario. Trottier (1973:9), for example, describes potential raw material sources near from Falcon and Lyons to Caddy lakes in southeastern Manitoba. Halverson (1988) reports locally extensive bedrock outcrops of chert on Stephen, Flint, Cameron and Kakagi lakes in northwestern Ontario, immediately east of Lake of the Woods. Pastershank (1989) reported three sites on an eastern bay of Lake of the Woods where cobbles of "Lake of the Woods Chert" had apparently been gathered and reduced. Rajnovich (1983:15) reports the local availability of chert and rhyolite at Spruce Point on the north end of Lake of the Woods. There is not good available information on the relative abundance of these raw materials in the vicinity of Lake of the Woods, although the literature creates that impression that they are certainly not uncommon. The availability or abundance of the Border Lakes Greenstone Group materials to the east-northeast is not clear. In glacial sediment to the south, Lake of the Woods Rhyolite is not especially common but neither is it rare. It may decrease in abundance with increased distance to the south, however. It appears that raw material sampling (e.g., Bakken 1985) has not documented the presence of Lake of the Wood Siltstone in glacial sediment to the south. This is more likely because the material was not recognized as a potential toolstone, however, than because it does not occur.

In sum, Knife Lake Siltstone varies in quality from superior to marginal; the former is more common to the north at or near the quarries, while the latter predominates to the south for till-derived materials. Very large pieces (potentially up to a meter) are available from the quarries, and boulders as large as 25 to 30 cm are available from the till. Large amounts of KLS are available from the quarries, and it also is relatively abundant in the till, at least locally (see Mulholland 2002; Mulholland and Menuey 2000) and may generally diminish to the south.

The Lake of the Woods materials appear to generally be of marginal to moderate flaking quality, although some Lake of the Woods Siltstone may be of relatively good quality. Relatively large pieces are probably available from bedrock sources; at least a few clasts in glacial sediment can be around 25 cm in diameter, although the more common size is probably on the order of 10 to 15 cm. The materials may be relatively common in the vicinity of Lake of the Woods. Broader availability remains unevaluated. Abundance in glacial sediment is somewhat low, and may diminish to the south.

Sioux Quartzite Group

The Sioux Quartzite Group may not be an especially important resource, but it deserves mention since these raw materials do show up at sites. The most widespread of these materials is Sioux Quartzite itself. This quartzite crops out at a number of locations in southern Minnesota, eastern South Dakota, and northwestern Iowa (Austin 1972:450-453; Sims and Morey 1972:3). No one has presented evidence for quarrying of these outcrops, although some of them were engraved with petroglyphs (Lothson 1976). Rather it seems that the Sioux Quartzite that was flaked consisted of clasts gathered from glacial till. The extent of distribution and relative abundance is not clear, although early glaciations spread pieces of this material as far as Nebraska (Carlson and Peacock 1975:Nehawka Flint) and Kansas (Aber 1991).

The other members of this group are pebbles and cobbles of various materials that come from the basal conglomerate of the Sioux Quartzite. These materials include "cemented cobbles and pebbles of quartz, quartzite, chert, siltstone, and inclusions which may be associated with iron-bearing formations including jasper-taconite" (Peterson et al. 1989). Outcrops are limited (Austin 1972), although a small outcrop near New Ulm was in fact used as a toolstone source (21NL59; Terrell et al. 2005).

Sioux Quartzite

Sioux Quartzite would seem to be a difficult material to flake, although no experimental verification was found. Two lines of indirect evidence may offer support of that assessment, however. Morrow (1994:108) notes that in Iowa, "This material was occasionally used for the production of chipped-stone tools but occurs most frequently in the source area in the form of ground stone items such as metates." Use of the quartzite to produce groundstone items like metates suggests that it could be relatively tough, and more amenable to pecking than to flaking. Also, the quartzite is very rarely reported as flaked stone tools or flaking debris (n=48, out of 643,206 in my overall sample), at least in Minnesota. This might be because it was seldom flaked. Alternatively, it could be because Sioux Quartzite flaking debris is difficult to identify. In my own inspection of assemblages from southwestern Minnesota, I saw pieces of broken Sioux Quartzite. Almost all of these pieces were very blocky and difficult to identify with any confidence as flaking debris. If they are in fact flaking debris, they probably present the best evidence for the poor flaking quality of this raw material. It might also be noted that the use of outcrops of Sioux Quartzite as the substrate for petroglyphs at the Jeffers site (Lothson 1976) could be taken to suggest that the material is more amenable to pecking than to flaking.

There is very little information on the package size for Sioux Quartzite. The material outcrops at a few locations in southwestern Minnesota, southeastern South Dakota, and northwestern Iowa (Austin 1972:450). The outcrops could theoretically provide blocks of raw material of unlimited size, provided that such blocks could be detached. The size range of glacially redistributed clasts was not determined.

Austin (1972:450-452) documents outcrops of the Sioux Quartzite in northern Rock and southern Pipestone counties; northern Cottonwood, southwestern Brown, and western Watonwan counties; and in Nicollet County near New Ulm. He also notes outcrops in southeastern South Dakota and extreme northwestern Iowa, without specifying outcrop locations. Such outcrops could theoretically have provided very large quantities of the material. Little specific information was found on the wider glacial distribution, although early glaciations spread pieces of this material as far as Nebraska (Carlson and Peacock 1975:Nehawka Flint) and Kansas (Aber 1991). No information was found on the relative abundance of Sioux Quartzite in glacial tills.

In sum, we can indirectly infer that Sioux Quartzite is a submarginal quality material at best. It occurs at scattered bedrock outcrops that may theoretically have provided large pieces of raw material, and in glacial sediment as clasts of unknown dimension. Scattered outcrops occur in restricted areas of Minnesota, South Dakota and Iowa; the glacial distribution ranges into Kansas and Nebraska. Information on relative local abundance is lacking.

Sioux Conglomerate Materials

The Sioux Quartzite, as a geologic unit rather than a raw material type, contains strata of different kinds of sedimentary rock. The predominant type is the quartzite discussed above. Catlinite (pipestone), which is geologically minor but culturally important, is another component. There are also beds of conglomerate, or rock consisting of clasts ranging from pebbles to cobbles and sometimes even small boulder that are cemented in a finer-grained matrix. These conglomerate beds are the source of the materials discussed here. Documented raw materials in the conglomerates include quartz, jasper, chert (including a "pink to cream finely crystalline chert" [Austin 1972:42]), iron formation, and quartzite.

Little information is available on the flaking quality of the Sioux Conglomerate materials. We might expect the quality to vary somewhat between the quartz, quartzite, chert, jasper and iron formation. Terrell et al. (2005:106), however, note "the generally poor quality of the lithic raw material" at a procurement site around the conglomerate outcrop at New Ulm. They further note (Terrell et al. 2005:100) that 100 of 144 recovered pieces of Sioux Conglomerate Quartzite were shatter, which may suggest relatively poor flaking quality.

Gresham (1916:69-70) notes that the clasts in the New Ulm conglomerate "are of all sizes up to a diameter of one foot or a little more." Austin (1972:452) describes "pebbles, cobbles, and small boulders as much as 13 inches in diameter." He further notes that the New Ulm exposure is the coarsest, indicating generally smaller clast sizes for other conglomerate exposures. This agrees with his observation for one of the Pipestone County outcrops, where he describes "pebble- and cobble-sized clasts." A photo in the report by Terrell et al. (2005:104) shows casts in the New Ulm conglomerate left by missing cobbles; these measure about 16 to 18 cm across, judging by a scale in the photo.

Regarding overall abundance, Austin (1972:452-453) documents a number of outcrops of the conglomerate in south-central to southwestern Minnesota. These include the outcrop at New Ulm, an outcrop in northern Cottonwood County, a number of outcrops generally south of Pipestone in Pipestone and Rock counties, and an outcrop near Garretson, South Dakota. Gresham (1916:69-70) notes that the New Ulm conglomerate "beds vary from one to six feet in thickness.... The pebbles in it... are generally abundant, often occurring nearly as thick as they could be packed."

Regarding relative abundance between the different materials found in the conglomerate, Gresham (1916:69-70) notes a strong predominance of jasper and quartz which "occur together in nearly equal abundance and dimensions." For the New Ulm exposure, Austin (1972:452) notes that "About half the detrital particles are composed of white vein quartz; the remaining clasts are composed of jasper, chert and chert iron-formation... in order of decreasing abundance." For an outcrop near Pipestone, he notes that the conglomerate is "composed primarily of vein quartz with red jasper, pink to cream finely crystalline chert, and some quartzite pebbles." For another Pipestone outcrop and the outcrop near Garretson, South Dakota, Austin (1972:453) notes that "about two-thirds of the clasts are vein quartz; the remainder are pink and cream, finely crystalline chert. Quartzite pebbles are not as common as in the other conglomerates."

In sum, the various raw material types contained in the Sioux Quartzite Conglomerate might vary somewhat in flaking quality, but the one available assessment suggests that none are of particularly good quality. Package size varies between outcrops, with pebbles and cobbles apparently common, and at least the New Ulm outcrop producing boulders up to around 30 cm in diameter. The materials would seem to be locally abundant at scattered outcrops in south-central to southwestern Minnesota and a nearby part of South Dakota. Quartz and jasper appear to be the most common, although there is variation between outcrops. Chert may be relatively abundant at some outcrops, and archaeological evidence from the New Ulm outcrop (Terrell et al. 2005) suggests that Sioux Conglomerate Quartzite was also abundant enough to constitute a large proportion of the lithic assemblage.

Western River Gravels Group

The Western River Gravels Group includes a number of raw materials originating from western sources, including sources as distant as the Rocky Mountains. The materials were first moved eastward as gravels along the courses of preglacial rivers. Later such gravel deposit were more widely spread by glacial ice. materials that occur in the form of small (under ca. 5 cm), rounded, well-weathered pebbles. This group designation is useful in the South Agassiz Region and possibly in the Pipestone Region.

The Western River Gravels Group is fairly well understood from a geological perspective. The first vector of transport for these materials was as pebbles in preglacial river gravels. These rivers originally flowed from the Rocky Mountains to Hudson Bay, and carried materials to the east from as far west as the Rocky Mountains. In many cases the upper reaches of these rivers still follow the same general course, but the lower reaches were diverted to new courses by glacial ice and now drain into the Gulf of Mexico via the Missouri and Mississippi rivers. Bluemle (1972) provides a useful, succinct overview of the issue of preglacial river drainage patterns and the nature of associated river gravels. Klassen (1969:2-9) documents the Souris gravel and sand in southwestern Manitoba. Lemke and Colton (1958), Collier and Thom (1918), and Petter (1956) document the related Flaxville gravels of North Dakota. The second vector of transport involved glacial entrainment of gravels from the abandoned, buried river valleys. The gravel was effectively diluted, then spread over a wide area as a thin distribution of pebbles of far western origin.

We do not yet, however, have much information about which specific raw materials belong to this group. Klassen (1969:2) notes that the Souris gravel and sand contain elevated percentages of lithologies of "western (Rocky Mountain) provenance" which "comprise a distinctive assemblage of subrounded to well-rounded quartzite, argillite, chert, agate and porphyritic volcanic rock types." Hlady (1965:6) reports that the gravels yield "agate of various colours and effects... 'Knife River Flint', yellow jasper, fossil wood and quartzite." (Note that the presence of Knife River Flint was effectively disputed by Syms (1977:32), and this is generally considered to be a misidentification.) Hlady further proposes that "It may well be that much of the limited amount of this material [yellow jasper] which is found in minute percentages in many Manitoba sites originated in those gravels." Haug (1976:26) reports "agates, petrified woods, and a light brown flint" from the gravels. My own observations suggest that the gravels contain Moss Agate (Yellowstone Agate), as well as a suite of distinctive but unidentified jaspers, quartzites, silicified woods, chalcedonies and possibly other materials.

Many of these materials should be amenable to specific identification given further research. This could be useful information to have, since it would help distinguish between the deliberate circulation into the region of raw materials from the far west on one hand, and the incidental occurrence of those same raw materials deriving from local pebbles on the other. Such specific identification could begin with a close look at raw material samples that have already been collected and that are reposited at the Minnesota Historical Society Archaeology Department, Fort Snelling. The study could be completed by collection and identification of additional samples from relevant parts of the state.

The quality of these materials remains unevaluated, pending experimental reduction or identification with known raw materials. Some appear to be of reasonably high flaking quality, others much less so. Their utility, however, is probably limited by the small size of the pieces. My impression is that these pebbles seldom exceed 4 to 5 cm in maximum dimension, at least when they are redistributed in glacial sediment. This observation should be subject to confirmation, however.

In the original gravel deposits, the siliceous pebbles are apparently locally very abundant. Klassen (1969:2) notes 10 to 75 percent of pebbles are of western origin. He further observes that the gravel deposits are as thick as 6 m in outcrops and 24 m in buried deposits. Note, however, that this abundance is quite localized. The gravels are limited to preglacial river valleys, and even with these valleys they are discontinuous. This abundance would be greatly diluted in the subsequent glacial distribution, since the glaciers redistributed only a part of the river gravels, and spread this part over a large area. The result seems to be that while these pebbles are not rare, neither are they common or locally abundant (except where the original river gravels crop out).

In sum, we have incomplete information on the Western River Gravel Group. We can tentatively conclude, however, that flaking quality ranges from high to perhaps moderate; that package size is small, seldom exceeding 4 to 5 cm; and that within the study area, the constituent materials are widespread, not rare but also not common.

Generic Local Raw Material Categories

These raw materials are not specifically defined by physical characteristics, distribution or source. In some cases this is because such definition is either impractical or of limited analytical value. In other cases, however, such definition is desirable but has not been done yet. In either case, it is usually difficult to provide good information on quality, package size or availability for minimally-defined materials. The following paragraphs present the available information, but this is somewhat irregular in detail and quality.

Quartz

Quartz is a complicated issue in regional raw material studies, and one that remains to be resolved. Quartz originates from a potentially large number of largely-unknown sources. It is widespread throughout the region (although not ubiquitous, as previously suggested; cf. LeVasseur 2000:12). There is also variation in flaking quality, although this is probably a bimodal distribution with a small peak at average quality (mostly recrystallized Fat Rock Quartz) and a much larger peak approximately on the border of marginal to submarginal quality (most other quartz).

This is probably not an analytical problem in most parts of the state. In these areas, the local resource base includes pebbles or cobbles of lower quality quartz that are reduced using a bipolar pebble-core strategy. Most or all quartz in many assemblages represents that resource base and reduction method. There is, however, a significant analytical problem in the Quartz Subregion of central to east-central Minnesota. In that area we have two different resources that differ in flaking quality, package size, distribution and in how they are used. However, they are (and quite understandably) indistinguishably mingled in all the available data. This puts an enormous analytical roadblock in the way of understanding raw material use in that part of the state. Until we can acquire a good-sized body of lithic data where these two resources are separated, it will be very difficult to make further progress in modeling raw material use for this archaeologically important part of the state.

That said, the characteristics of Fat Rock Quartz are examined above. The general characteristics of other quartz are examined here. Information on this material is widely scattered and difficult to gather. This summary depends in good part on personal impressions gathered over a long period, and should be considered provisional and be subject to review.

Romano (1991d:6) calls the quartz of east-central to northeastern Minnesota "a very difficult material to knap." Based on my own observations and on experimental reduction conducted by Wendt (personal communication 5 October 2006), the flaking quality of most regional quartz is quite poor. Many pieces shatter on impact into small chunks, and are completely unworkable. Some pieces will produce sharp flakes or, less often, a small core than can be bifacially reduced to a projectile point or other tool. Overall, flaking quality probably bridges the marginal to submarginal categories (with the unworkable pieces lying past the submarginal category).

Quartz probably occurs as pebbles over most of its range, and as cobbles in parts of that range. Boulders and larger veins in bedrock probably have a limited distribution. Halverson (1988:45), for example, notes veins and larger pieces of quartz on parts of Lake of the Woods, including "large veins of quartz... with evidence of bashing on them." Since quartz is apparently coming from a large number of unknown sources, it is difficult to evaluate the vectors of transport and the redistribution of this material. Thus it is also difficult to infer patterning in the overall distribution of the material. A better understanding of the distribution of flaking quality, package size and abundance will likely only yield to the accumulation of many local observations or an extensive and systematic raw material survey. As previously discussed, it is not clear that the results will justify the effort in the case of quartz.

Romano (1991d:6) reports substantial "quarrying activity on the Darky [sic] River portage on Minn Lake near Lac La Croix, Ontario," suggesting local abundance of the material. Beyond that, I am presently unable to offer much information about relative local abundance of quartz, beyond the general observation that it appears to be much more abundant in the Quartz Subregion.

In sum, the flaking quality of quartz appears to vary from marginal to submarginal. It is probably available as pebbles over a wide area, cobbles in more restricted areas, and larger pieces in a handful of areas. We know little about relative abundance, beyond the general observation that quartz is probably much more abundant in the Quartz Subregion.

Quartzite

The quartzites found in the till vary in their physical characteristics. The variation is probably not very important, however, since these materials do not seem to be important as toolstone. Limited informal testing suggests that these quartzites are often relative weak and friable, and thus poorly suited to tool production. It is possible that such quartzite cobbles were used mostly as hammerstones rather than toolstone. This could account for the presence of small amounts of flaking debris (incidentally detached from hammerstones) and the lack of tools. This "hammerstone hypothesis" should, however, not be accepted without critical review.

My impression, based on raw material sampling, is that till quartzites occur as cobbles and pebbles, probably seldom exceeding 10 to 12 cm in diameter. Many of the pieces are round to subround, with an exception. It is not uncommon to find flat, oval pebbles that look much like beach shingles. These were probably shaped in a different environment, and are treated as part of the Western River Gravels Group.

Quartzite clasts are not uncommon in some parts of the state, including areas where Des Moines lobe till is exposed. The overall statewide distribution is not clear. The map of its archaeological occurrence, however, suggests that it is widely distributed. Morrow (1994:118) notes that "Metamorphic quartzites [are] common in glacial gravels throughout much of Iowa."

Note that these observations do not preclude the existence of better quality quartzites that have not yet been recognized, whether they come from till or bedrock. We can infer, however, that any such undiscovered quartzites are likely to be limited in their distribution and use since they have not specifically been identified by this point.

In sum, the quartzites found in till are of limited importance as toolstone. Their flaking quality is poor, and quartzite cobbles may have been used mostly as hammerstones. Quartzite clasts commonly occur as pebbles and cobbles, and may be fairly widely distributed around the state.

Basaltic Rock

This category was proposed by Ahler (1977:139), who used it to subsume "all dense, dark colored, fine-grained, igneous or metamorphic stones having poor flaking qualities." The category is hard to defend from a geological perspective (a fact that Ahler notes), since it mixes rocks of entirely different origins based on somewhat superficial characteristics. The term has proven to be very useful archaeologically, however, and its continued use is recommended. It provides a way to identify and group a set of raw materials that have rather narrow, specialized uses and that probably do not merit specific identification and further study.

The category of basaltic rock does include true basalts, but also includes metamorphic materials like gneisses and has expanded to metasedimentary materials like slates and graywackes as well. They all share marginal to submarginal flaking characteristics, and were not part of the mainstream raw material economy. In some cases, they were used as hammerstones in the manner discussed above for quartzites. A more important use – or at least a use that has a larger presence in lithic assemblages – is the production of chopping tools. These core tools have a very short production trajectory (rough bifacial trimming of one thin edge) and fairly basic edge-configuration requirements. They also seem to have a short use-life. The flaking properties of the stone are probably less important than the configuration of the cobble. It should have an appropriate size, a shape that is somewhat more lenticular than rounded, and at least one relatively thin edge that can be quickly and easily dressed.

Since this category is so broadly inclusive, it is likely to include materials with a wide range of flaking characteristics, package size and availability. This is not necessarily problematic, however, since basaltic rock is not part of mainstream flaked-stone technology. Raw material flaking quality is not really an issue since the resulting flakes are not used, edge configuration is not critical, and the edge does not need to stand up to long use or be resharpened. The range of package sizes is also not critical since it seems there was deliberate selection for cobble-size pieces of a convenient size to be held in the hand, and of such a shape as to present a thin edge. Availability can be considered broad, since many kinds of materials could be used. Relative abundance would certainly vary from place to place, but there is probably no feasible way to assess this.

Note that in some cases, researchers may specifically identify basalt in a stricter sense. The difference in usage should be apparent in such a context. In such a case, the material may support some technology other than chopping tools. At 21WA93, for example, basalt cobbles were flaked as the first stage in making groundstone tools (Fleming 2002). It might be desirable at some point to define and name one or more types of actual basalt, with reference to specific sources, distributions, and physical characteristics. This will require a careful review of not only regional geology, but also regional use of basalt in the archaeological record.

Granitic Rock

This category is also widely and informally used to subsume a set of materials that are more coarsely crystalline than the "basaltic rocks." Color can vary from light to dark, and flaking quality is poor. The category includes materials such as granite, diorite, and probably relatively weakly metamorphosed forms of similar rock. Since the category is so broadly inclusive, it is likely to include materials of diverse flaking quality, package size and abundance. This is not necessarily problematic, since granitic rock is not part of mainstream flaked-stone technology. Its use is probably restricted to hammerstones, and associated flaking debris found in lithic assemblages represents damage to the hammerstone rather than deliberate flaking (although a small amount may represent misclassified fire-cracked rock from fire hearths, sweat lodges or other uses). If this is the case, the raw material characteristics are of little concern.

Rhyolite

In addition to Lake of the Woods Rhyolite, some other kinds of rhyolite occur in the state and region. Limited information is available for most of these (with the exception of a material like Marquette Rhyolite in eastern Wisconsin [Behm 1991; see also Moffat and Speth 1999:133]).

Romano (personal communication 23 May 2003, 8 September 2005), for example, mentions a rhyolite that is "fine grained (no visible crystals with naked eye), reddish brown,

[and] contains feldspar inclusions." He notes that it has a "conchoidal fracture, but is not a superior knapping material" (Romano, personal communication 13 May 2003), that it can be found in wide range of sizes and shapes, and that it is abundant along the North Shore of Lake Superior (Romano, personal communication 25 Jul 2005). Wendt (personal communication 6 April 2004) mentions a possible source west of the Split Rock lighthouse, pointed out to him by Don Minuei.

Goltz (personal communication 6 Feb 2001) mentions a rhyolite that is "light whitish-gray to white, and very translucent" with "almost a frosty look, but some of the heat treated stuff is almost waxy here and there. It takes on various light pinkish to orangish tones (quite variable) after heat treating." He further mentions finding a piece of this material measuring about 20 to 25 cm in Crow Wing County, and a report that the material also occurred in sites west of Thunder Bay. Goltz (2001) also mentions "a brownish purple rhyolite with glassy phenocrysts... [that is] common on PaleoIndian context sites" in the Mississippi Headwaters region of northern Minnesota.

Until these materials have been better studied and defined, it will be difficult to understand their place in raw material use strategies.

Major Exotics

As previously discussed, there are only three exotic raw materials that are regularly found at archaeological sites in Minnesota. These are Knife River Flint, Hixton Quartzite and its allies, and Burlington Chert. These three and obsidian are the only exotics treated in the following pages. Although obsidian is regionally rare, it is included because it has a certain diagnostic significance. Note that in the case of Hixton Quartzite and its allies, definition of a raw material group helps resolve inconsistencies in the identification of the associated materials, and somewhat simplifies analysis and discussion.

Knife River Flint

Understanding the distribution and use of Knife River Flint in the Upper Midwest requires distinguishing between primary and secondary source areas (sensu Gregg 1987a). These paragraphs deal with KRF in and near the primary source area. A separate discussion above deals with the broader distribution of KRF in secondary source areas.

Ahler (1983:1) maintains that "Knife River Flint in raw form was one of the higher quality, more flakeable stones in North America." More specifically he notes that KRF has

> good conchoidal fracture properties, subject to well-controlled flaking by either percussion of pressure techniques. In raw form, most KRF would be assigned by this author to grade 3.0 on Callahan's (1979:16) lithic grading scale. According to Callahan, this grade includes the finest grade flints such as those from Georgetown, Texas and Brandon and Dover, England. [Ahler 1983:2]

He reports that heat treating improves flakeability to "about 2.0 to 2.5 on Callahan's (1979:16) lithic grading scale, comparable in quality to some other heated fine-grained flints and Wagner, Arizona basalt" (Ahler 1983:5).

Ahler also reports that in the primary source area, KRF occurs in "Pleistocene age alluvial and colluvial deposits in Dunn and Mercer Counties, North Dakota, where it occurs as pebbles, cobbles and small boulders" (Ahler 1983:3). Clayton et al. (1970:284) similarly report "subangular pebbles, cobbles, and boulders as large as 2 feet in diameter" in the primary source area of Dunn and Mercer counties. For the same general region, Loendorf et al. (1984:7) report that "The largest cobbles can be forty centimeters in length, but more normally the cobbles are eight to fifteen centimeters in length; it is quite possible that the larger cobbles were selected by the aboriginal artisans, leaving the smaller fragments in the modern sample." Artz (1985:122) reports "near the Killdeers, large cobbles of good quality KRF up to 15 cm in diameter." M. Doperalski (personal communication 25 Oct 2007) reports a sample collected just west of Bismarck that measures 51 by 43 by 12 cm and other pieces that were "much larger... but they are too heavy for one person to carry."

Clayton et al. (1970:294-285) report that "The greatest observed concentrations of flint in the gravel are at quarry sites, where alluvial, lag, and slope-wash deposits consist largely of cobbles and boulders of Knife River Flint" and that "The flint has been observed in lesser amounts at numerous other places throughout western North Dakota." For the Killdeer source, Artz (1985:122) also reports "abundantly concentrated" large KRF cobbles. Wendt (personal communication 1 May 2006) reports finding "pieces of KRF everywhere I looked across 5 counties including the parking lot at Subway in Bismarck." I have observed a similar abundance of KRF in roadcuts, fields, and other exposures in Buelah, to the northwest of Bismarck.

In sum, Knife River Flint is a superior-quality raw material. With proper heat treatment, it ranks among some of the most flakeable raw materials in or beyond North America. It is widely available in pieces up to about 15 cm, and in some areas can be found in pieces measuring 40 to 50 cm or more. It is also abundant over a sizeable area of western North Dakota.

Hixton Group

The new term Hixton Group is proposed here in response to problems with how Hixton and allied quartzites are referred to within the region but outside of their primary source area. Hixton Quartzite was identified and described relatively early (e.g., Brown 1907, 1984 [manuscript ca. 1933, see Behm 1984]; Porter 1961), and use of the term Hixton was well established by the time related but distinguishable quartzites were described in the region (e.g., Boszhardt 1994; Carr and Boszhardt 2003; Penman 1984). Archaeologists working outside the primary source area of these quartzites have often kept using the term Hixton to refer to all of these materials. In part this may be because it is challenging to distinguish between the related quartzites without extended practice or expert tutelage. At a distance from the main source area, the practice is maybe not so problematic since all the materials originate from the same approximate distance and direction. Overly-broad use of the term Hixton *is* problematic, however, in the sense that it indicates origin from a very specific source. Using the name Hixton for Alma Quartzite, for example, is simply inaccurate.

One solution to this problem is to create a raw material category that includes Hixton, Arcadia Ridge, Alma, Cascade and other related quartzites from west-central Wisconsin and possibly southeastern Minnesota. This broader term can then be accurately used to indicate region and geology of origin, while avoiding the need to more specifically identify the raw material given a lack of adequate expertise. It has proven difficult to find a suitable name for this group, either geologic or geographic. In the end, it seemed less problematic to simply use the term Hixton Group, referencing the best known material in the group. Although this may be less than ideal in some regards, it does have the advantage of paralleling current usage, a factor that may help promote use of the new term.

Although this group includes a number of raw materials with some variation in characteristics, the information presented here focuses on Hixton Quartzite itself since Silver Mound, the Hixton source, evidences intensive, long-term use in contrast to the more limited use of materials from other sources.

There seems to be some disagreement about the flaking quality of Hixton Quartzite itself; it is not clear to what degree these varied opinions reflect a range of quality in the raw material, or even the types of techniques required for successful reduction. Boszhardt

(1998a:87) notes that "As an indication of the relative quality of Hixton Silicified Sandstone, modern flintknappers continue to prize the 'sugar quartz' or 'candy' of Silver Mound." Behm and Faulkner (1974:272) call it

> an extremely tenacious flintworking material. Effective thinning of this substance by percussion flaking may be accomplished by using a heavy, hardwood mallet or similar baton and striking the quartzite with great force. Attempts at using soft or hard hammerstone techniques generally fail, resulting in repeated step fractures and other, similar, undesirable effects. Furthermore, pressure flaking of this material requires extreme effort and has been successfully accomplished by very few modern experimenters.

Withrow (1983:41) notes that "some specimens exhibit a very fine conchoidal fracture" but also reports Callahan's (1979:16) observations that finer Hixton Quartzite rates 4.0 and coarser Hixton 4.5 on his scale of 1.0 to 5.5 – with 5.5 being unworkable.

Regarding the broader Hixton Group, Boszhardt (1998a:89) notes that

> Macroscopically, western Wisconsin orthoquartzite shows considerable overlap in texture and color across and within sources. The best-quality Hixton Silicified Sandstone seems to be more pure and better cemented than most others. However, other sources (particularly from the Four Corners area) contain some very good quality material, and Hixton grades into mediocre or less well cemented layers.

For the Arcadia Ridge source area, he notes more specifically that "The texture was described as ranging from coarse, poorly cemented to finer grained, harder material..." (Boszhardt 1994:3) and that "In comparison to Silver Mound... the orthoquartzite outcrops on Arcadia Ridge are not extensive and the material is relative poor quality" (Boszhardt 1994:29). For a secondary glacial source (but apparently near the primary source) in Dunn County, Wendt (personal communication 16 June 2004) reports that the larger pieces are coarse grained, but that there were also "smaller rounded pebbles of silicified sandstone in the glacial till. Some of these pieces are much higher quality."

Regarding package size, Brown (1984:162) reported "two large pieces of quartzite, three feet in length, from nine inches to a foot wide, and four inches thick" at Silver Mound. For the Alma Quartzite source, Penman (1984:3-4) reports that "Boulders (over two meters in diameter) of this material occur at the bluff base and are readily visible." For the Arcadia Ridge Quartzite source, Boszhardt (1994:3) reports that "Orthoquartzite is exposed at the tip of Never Assume in a one meter thick ledge. Similar outcrops occur at least five other locations on the ridge." For the Dunn County source, Wendt (personal communication 16 June 2004) reports "large blocks" of up to 30 pounds in weight.

Boszhardt (1994:25) provides an overview of the geographic distribution of Hixton Group quartzites: "It is now apparent that orthoquartzite occurs over much of western Wisconsin, corresponding to the distribution of exposed Cambrian sandstone. Currently, orthoquartzite has been documented from multiple sources in Buffalo, Trempealeau, Jackson, Monroe and La Crosse counties (Figure 20)." Wendt's observations (personal communication 16 June 2004) add Dunn County to this list. Over this area, abundance of supply and intensity of use can vary considerably. Regarding abundance of raw material at the various sources, Behm (1984:169) characterizes Silver Mound as "one of the largest and most extensively worked quarry and workshop sites in the upper Midwest." Hill (1994:226) notes that

> In spite of modern landscape alteration and Euroamerican mining activities, Silver Mound is still pocked with hundreds of pristine prehistoric quarry pits and trenches. Several rockshelters that appear to have served as quarry/workshop and occupation sites are also present.... The mound and neighboring field... are littered with lithic debitage and artifacts spanning thousands of years.

In contrast, Boszhardt (1994:29) notes that "In comparison to Silver Mound... the orthoquartzite outcrops on Arcadia Ridge are not extensive and the material is relatively poor quality," and that for one of the outcrops "no evidence of prehistoric digging/quarrying was found. Instead, only naturally exposed orthoquartzite seems to have been selected" (Boszhardt 1994:18). Regarding Alma Quartzite, (Penman 1984:7-8) notes that the "Synstad workshop covers approximately five acres." Regarding the Dunn County material, Wendt (personal communication 16 June 2004) reports that "Large blocks of it cover the hilltops at the eastern edge of the Prairie Du Chien escarpment," suggesting relative abundance.

In addition to the mainly primary sources, Gonsior (1996:10) reports

> glacial till deposits on top of bluffs along the Mississippi River near Cochrane, Wisconsin, where the underlying bedrock is the Prairie du Chien Formation. Apparently this is a secondary deposit, since the till contains cobbles and boulders of Cochrane Chert, Alma Quartzite, and a variety of material from the Lake Superior region including Animikie Silicates (i.e., Jasper Taconite).

This indicates a broader (and presumably thinner) glacial distribution of at least some Hixton Group materials.

In sum, the Hixton Group quartzites have variable flaking quality and there are varying opinions about their flaking quality. However, at least some of the material was of good (or better) quality. Package size is very large, reaching or exceeding a meter for some sources. In general, the materials seems to be relatively abundant, with Silver Mound representing a major raw material source.

Burlington Chert

Morrow (1984a, 1994) defines three principal varieties of Burlington Chert – mottled white, mottled gray and tan, and fossiliferous – and notes that "Burlington white mottled chert is the most common variety obtained from the Burlington Formation." These varieties are not used by all of the researchers cited below. From the perspective of Minnesota this is probably not especially important, however, since any variety of Burlington would be coming from generally the same direction and distance.

Morrow (1983:16) calls Burlington Chert "one of the highest quality lithic materials available in eastern Iowa, if not the highest." He further observes that "In terms of relative abundance, nodule size, lack of inclusions, and fine grained texture, the typical white Burlington chert is essentially unchallenged as the best chipped-stone raw material obtainable in the state" (Morrow 1983:16). Rick (1978) notes, however, that Burlington occurs in a wide range of textures and qualities and that heat treatment significantly improves the flaking characteristics of most samples.

Morrow (1983:13) further observes that "Isolated lens shaped nodules or relatively continuous layers of nodules up to 30 cm. thick are not uncommon." He later amends this to note that the material "occurs in nodules and nodular beds up to 50 cm thick" (Morrow 1994:123). It is not quite clear whether these measurements apply to individual pieces or to the nodular beds. However, Meyers (1970:23) notes that the "chert varies from tiny nodules less than one inch in diameter to large, irregular masses a foot [30 cm] or more thick and several feet in length and width."

Rick (1978:6) notes that the 60 m thick Burlington Limestone "contains massive quantities of nodular chert." Speaking specifically of the Crescent Hills quarry complex, Ives (1975:3) quotes Fowke (1928:533-536) who notes that "The slopes are everywhere covered with an immense quantity of debris" and that this debris cover "is practically continuous and unbroken" for a considerable distance. Ives (1975:5) also notes that the Crescent Hills quarry district alone comprises about 44 square miles. Meyers (1970:23) notes that "in most outcrops along the edges of the valley (particularly those containing the Burlington Limestones) they [the bluffs] contain abundant chert beds and layers of nodules" and that

"The Burlington [Limestone] contains enormous quantities of white, yellow, and gray fossiliferous chert."

In sum, Burlington Chert is a very good to superior-quality raw material. It is available in large pieces, in some places as beds 30 cm thick and several feet in length. It is abundant parts of southeastern Iowa, northeastern Missouri and west-central Illinois.

Obsidian

The study of obsidian is a specialty within lithic raw material studies, one that is too extensive to recapitulate here. In addition, while obsidian can be important as a diagnostic marker and indicator of long-distance connections, it is not truly important in an economic sense. It constitutes only a fraction of a percent of lithic artifacts in the state and region. The details of its physical characteristics and abundance are not truly relevant, in the sense that they are for regional materials. For the sake of completeness, however, a brief summary is included.

Obsidian is a superior-quality flaking material that forms a dangerously sharp edge, although the material can be somewhat brittle and edges therefore somewhat weak (cf. Callahan 1979). Package size at the various obsidian sources was not reviewed, since it looks like obsidian nearly always arrived in this region in the form of finished tools. Many obsidian sources have been identified, especially in western North America. Analysis shows, however, that most obsidian occurring in Minnesota and the Upper Midwest comes from the Yellowstone source (e.g., Anderson et al. 1986; Hughes 2007). A reported obsidian source in the Black Hills is very limited in extent, and probably not of toolstone grade (cf. Alex 1977; Baugh and Nelson 1988; Darton 1912; Kirchner 1977; Redden 1983). Theoretically pebbles of obsidian could occur in the preglacial gravels that were widely (and thinly) distributed by recent glaciation. The brittleness of the material, however, reduces its chances of surviving either fluvial or glacial transport. A glassy pebble collected in Fillmore County, Minnesota, and initially thought to possibly represent an obsidian pebble as part of the Western River Gravels Group, was subsequently shown to be glassy slag (Hughes, personal communication to Emerson 17 June 2007).

Other Selected Nonlocal Raw Materials

A variety of nonlocal raw materials are occasionally found at archaeological sites in Minnesota. Most of these are sufficiently uncommon, however, that they do not seem to merit inclusion in the following discussion. Two raw materials, or better said two sets of materials, occur more frequently in some parts of the state. These are Maynes Creek Chert and Pennsylvanian fusilinid cherts. They are also included because the literature includes good information on their sources, distributions, and physical characteristics. Note that in the case of the Pennsylvanian fusilinid cherts, definition of a raw material group helps resolve inconsistencies in the identification of the associated materials, and somewhat simplify analysis and discussion.

Fusilinid Group

The Fusilinid Group includes a number of Pennsylvanian cherts that are found in parts of Missouri, Iowa, Kansas and Nebraska (see Morrow 1994:118; Reid 1980:122). These cherts tend to be medium to dark in color, and contain scattered to abundant fossils called fusilinids. Reid (1980, 1981, 1984) and Morrow (1984a, 1994) describe seven different Fusilinid Group cherts, with the caveat that this set of materials is not adequately understood and probably includes other cherts as well. The specifically described Fusilinid Group cherts include Argentine, Ervine, Plattsmouth, Spring Branch, Spring Hill, Westerville and Winterset.

Closer to the source area, these materials are usually identified to specific chert type. As with the Hixton Group quartzites, however, it can be challenging to distinguish between these related cherts without extended practice or expert tutelage. Minnesota archaeologists might have little trouble identifying fusilinid cherts at the group level, but considerably more difficulty assigning a specimen to a particular chert type. Use of the Fusilinid Group category affords a way to still provide useful information on the distance and direction of the raw material source, while sidestepping the need for more specific material identification.

Definition of the Fusilinid Group actually represents a minor adjustment to terminology. For some time it has been common for Minnesota archaeologists to use the term "fusilinid chert" in the same way suggested for the term Fusilinid Group. This seems to have worked fine, and the group definition is proposed here only to help standardize terminology and create greater parallel with the other groups proposed above.

Reid (1980) provides a general comparative evaluation of the flaking qualities of four cherts of the Fusilinid Group. He notes that some regional archaeologists found the Fusilinid cherts generally inferior to eastern Missouri materials (presumably Burlington). He also noted that the generally blocky or tabular shape of the pieces creates certain logistical problems in some reduction sequences, and that calcite veins in Winterset Chert interfere with flaking. Carlson and Peacock (1975:Nehawka Flint) notes that "Pieces with wide prehistoric distribution have good conchoidal fracture." The Fusilinid Group cherts found at sites in Minnesota looks relatively fine grained and homogenous, which suggests good flaking quality. This is admittedly a subjective assessment, however.

Gradwhol (1969:15) describes "Large flint nodules" at a limestone exposure in Nebraska. For sources in Iowa, Morrow (1994:126, 127) describes "irregular nodular masses," "irregular nodules" and "nodules" with maximum sizes variously 15 to 20 cm. For source in Missouri, Reid (1980) describes both tabular and nodular pieces, with maximum size exceeding 256 mm (blocks and boulders) for most varieties. He also notes, however, that the nodular pieces tend to break into blocky pieces, so the available raw material stock is mostly tabular, angular pieces.

The availability and abundance of these materials is difficult to assess based on available information. The primary source area, however, includes northwestern Missouri, southwestern Iowa, part of eastern Kansas and a small part of southeastern Nebraska (see Morrow 1994:118; Reid 1980:122).

In sum, Fusilinid Group cherts are of generally good quality. Size varies, but pieces in the 15 to 20 cm range are probably common. Availability and abundance are difficult to assess.

Maynes Creek Chert

Morrow (1984a:101, 1994:121-122) identifies five varieties of Maynes Creek Chert (cream, speckled, fossiliferous, gray, and green), distinguishing them based on physical characteristics and source. Archaeologist in Minnesota, however, seldom identify Maynes Creek to specific variety. My observation is that most if not all of the Maynes Creek Chert found in Minnesota is the speckled variety (although occurrence of the other varieties should no be ruled out, especially cream). Note especially Morrow's (1982:8) observation that "Maynes Creek Speckled chert is both diagnostic in appearance and common on archaeological sites. The speckled chert offers perhaps the greatest utility in lithic source analysis of all the five Maynes Creek varieties."

The prevalence of the speckled variety somewhat accords with Morrow's observations on the archaeological use of the five varieties. Gray and green are rarely seen outside the source area; fossiliferous "is not nearly as common as the other varieties" (Morrow 1994:122); cream is abundant in central Iowa and "occasionally shows up in other regions of the state" (Morrow 1994:121); and speckled "is commonly encountered on sites in central Iowa. Use of this material seems to have been particularly widespread from late Paleoindian through Late Archaic time" and the material "has been identified in small amounts in many parts of Iowa" (Morrow 1994:122). Therefore this description focuses on the speckled variety, with some information on the cream variety.

Morrow (1982:4) observes that "Maynes Creek Speckled chert is a fairly high quality chert after heat treatment." He particularly stresses the importance of heat treatment for all varieties of this material, noting that heat treatment apparently took place early in the reduction sequence.

Morrow (1994:121) notes that the speckled variety "occurs in nodules and fragments up to 30 cm in diameter," and that the cream variety "occurs in nodules and nodular beds up to 30 cm thick."

I did not find specific information on the abundance of Maynes Creek Chert. Morrow notes that the source strata outcrop "over a broad area of central Iowa" (Morrow 1984a:101) and that "Concentrations of archaeological materials in the Maynes Creek outcrop area suggest that quarrying chert was prehistorically an important activity in the area, particularly in southeast Hardin and southern Grundy Counties" (Morrow 1982:7).

In sum, at least Maynes Creek Speckled Chert is a good quality material when heat treated. This and the cream variety occur in pieces measuring up to 30 cm. Information on abundance is incomplete, but Hardin and Grundy counties are noted as important source areas.

CHAPTER 4. LITHIC RAW MATERIAL USE IN MINNESOTA AND REGION

He despaired of analysis; the real world was
always more fine-grained than opinions about it.
— Gregory Benford

THE NATURE OF THE RESEARCH PROBLEM

The regional raw material resource model presented in Chapter 3 gets us some way towards understanding raw material use. It helps us see what elements of raw material variation between assemblages can be attributed to variation in toolstone availability. That still leaves us, however, with the remaining variation to account for. Trying to understand the remaining variation – as part of a larger raw material economy and lithic technology – is the concern of the present chapter.

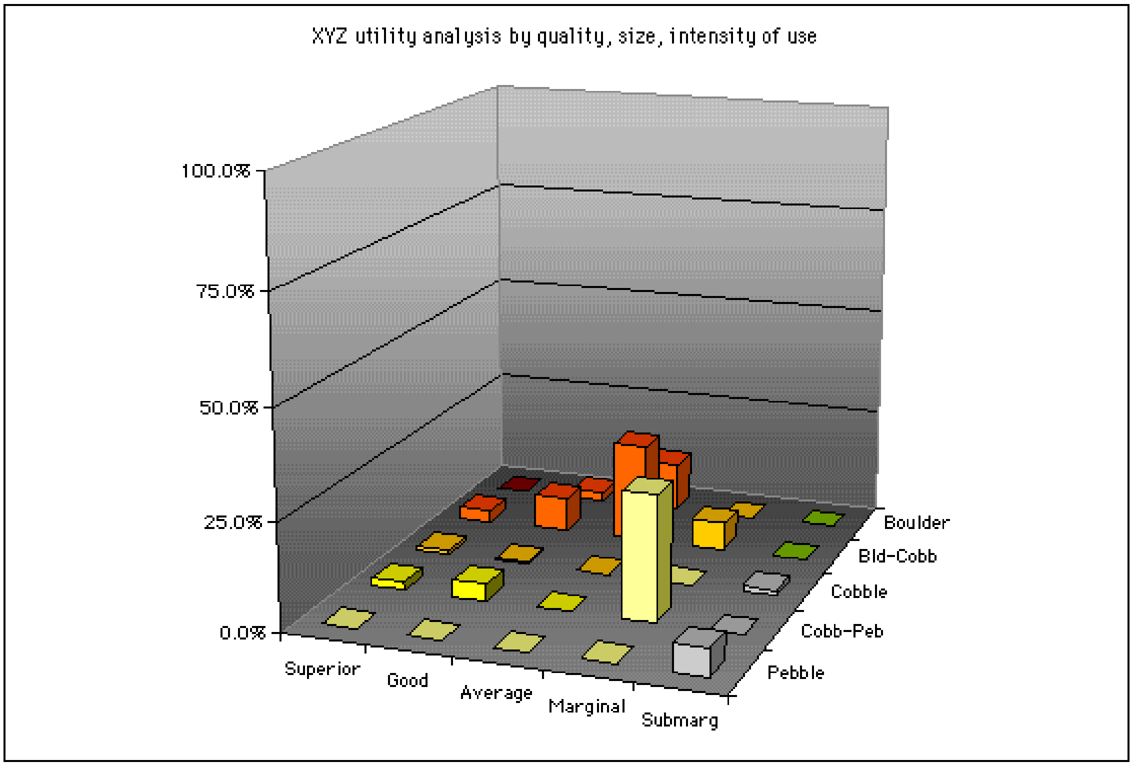
Before we begin exploring use patterns themselves, however, it may be helpful to consider the nature of the problem that we are trying to solve. We can do this by looking at a few selected assemblages from around the region, and using these to illustrate the kinds of questions that arise in connection with understanding raw material use.

Illustrating the Nature of the Problem

A few selected assemblages are presented in summary below to illustrate the discussion. Two kinds of assemblages are highlighted. The first set includes assemblages that are generally the same age but located in different parts of the state. These illustrate variation between regions in what could be otherwise-comparable assemblages. The second set includes assemblages from multicomponent sites. These illustrate variation within regions through time, at sites where we would expect raw material availability to be more or less the same in different periods.

The Bradbury Brook (21ML42) site is located a few miles south of Mille Lacs Lake in east-central Minnesota. Investigators concluded that the site represented procurement and initial reduction of Knife Lake Siltstone gathered from glacial sediment (Malik and Bakken 1999). The site included two concentrated artifact scatters representing initial lithic reduction, and a scatter interpreted as a contemporaneous campsite. Nearly all of the 100,000-plus lithic artifacts were KLS. Tools included flaked stone adzes, keeled scrapers,

Figure 4-1. Example of the utility analysis XYZ conceptual space.



and the base of a Paleoindian Alberta point. A pit feature packed with flaking debris, broken hammerstones and broken anvilstones yielded a small charcoal sample that was AMS dated to 9220 ± 75 BP.

The Greenbush Borrow Pit site (21RO11) is located on a Campbell beach ridge of glacial Lake Agassiz in far northwestern Minnesota, a few miles south of the Manitoba border (Peterson 1973). Investigators concluded that the site represented procurement and initial reduction of Swan River Chert gathered from the gravel beach ridge. SRC constituted 87.0 percent of the assemblage, Lake of the Woods Rhyolite contributed an additional 4.7 percent, and there were smaller amounts of Red River Chert, Knife River Flint and a few other raw materials. Diagnostic artifacts included a few rather roughly made lanceolate points, probably unfinished, that resemble the Agate Basin type.

Halverson (1992:62) and Hamilton (1996:74) summarize raw material composition for a number of Late Paleoindian sites in the vicinity of Thunder Bay, northwestern Ontario. Between them, they give raw material profiles for eight sites and one multi-site survey. For eight of the nine data sets, the percentage of Jasper Taconite ranges from 90.2 to 100.0 percent, averaging 96.5 percent. At the ninth site, Harstone Hill (DcJj-11), the percentage of Jasper Taconite is only 76.3 percent. We can also look at these assemblages from the perspective of percentage of all Animikie Group raw materials. In that case, the percentage for Harstone Hill jumps to 96.4. For all the assemblages, the resulting percentages range from 95.1 to 100.0 and average 98.6. Tools from the sites included a number of lanceolate biface fragments.

These three examples are more or less contemporaneous. They all include large lanceolate bifaces, and presumably share many other aspects of lithic technology (cf. Buchner 1979, 1981, 1984; Fox 1975, 1980; Harrison et al. 1995). But they are in different resource regions and include substantially different sets of raw materials. In the case of the Ontario sites, the researchers point to a strong preference by Paleoindian flintknappers for bedrock raw materials. At Bradbury and Greenbush, however, the Paleoindian flintknappers were using material taken from glacial sediments. Jasper Taconite, the preferred raw material at the Ontario sites, is fairly fine grained and flakeable, although many pieces tend to break into blocky pieces when struck. Swan River Chert, the preferred material at Greenbush, is less fine grained and much less flakeable. SRC is not adequately brittle, and it can be difficult to initiate fractures in the material. There is, in fact, some evidence that heat treatment commonly occurred between cobble testing and preliminary reduction, in order to render the raw material workable. Knife Lake Siltstone, the preferred material at Bradbury Brook, is generally fine grained and highly flakeable at bedrock sources to the north (cf. Nelson 1992), but the till-derived KLS found at Bradbury is not especially homogenous or good quality.

Here we have sites with much in common, including aspects of lithic technology, but the use of very different raw materials from different kinds of sources. The only obvious common element in raw material use is the focus on a single raw material that forms most of the assemblage. Is this significant, and does it indicate some common raw material use strategy? If it does, what kind of elements should we be looking for and how do we go about looking for them?

A different kind of example is seen at multiple-component sites. Some of these have clearly separated components, while others have deep artifact-bearing sediments with changes in raw material composition from top to bottom.

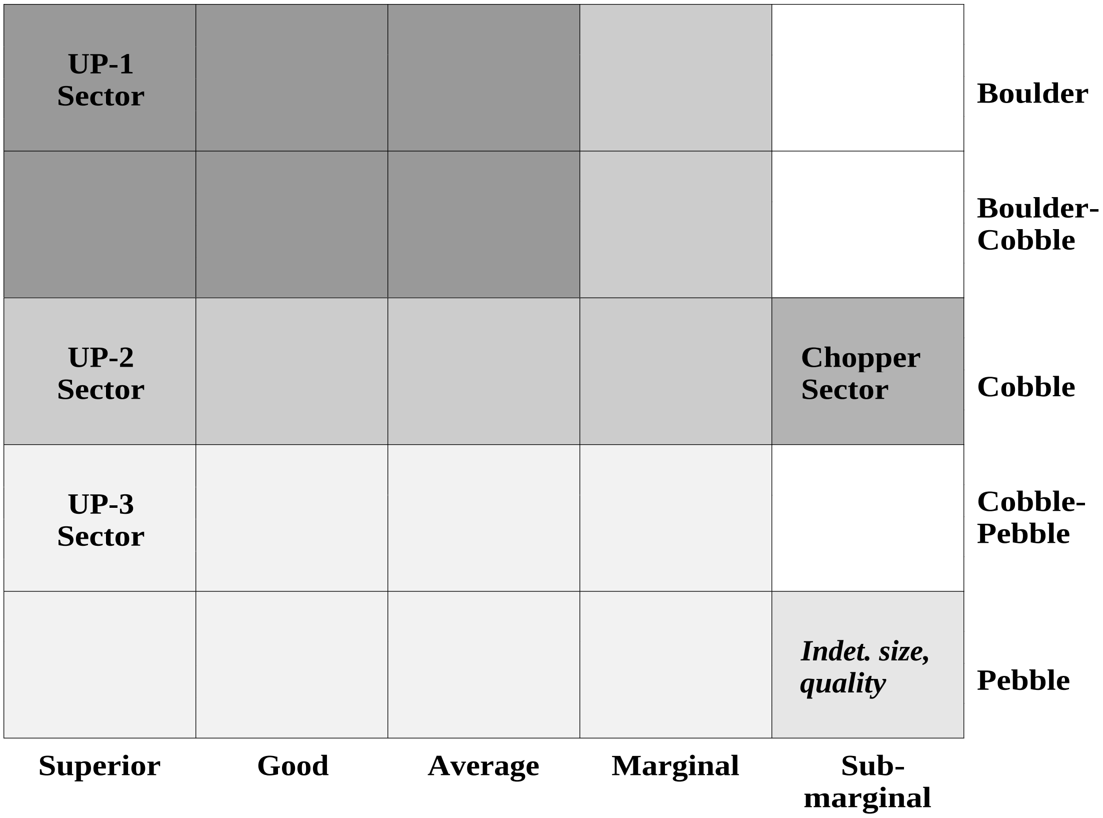
One example comes from the Thorkelson site (21RN19) near the Minnesota River in southwestern Minnesota, where we find some stratigraphic separation of upper and lower components (Gonsior and Yourd 1990). The more sparse upper component (n=30) occurs in the first 30 cm; the lower component (n=279) occurs below that, with the depth varying at different position on the landscape. A limited geomorphological reconstruction suggested that the lower component might be Late Paleoindian or Early Archaic; both components appear to be aceramic. The lower component consists mostly of Swan River Chert (%=98.6). The upper component, in contrast, has less SRC (%=63.3), a significant amount of quartz (%=16.7), as well as some Tongue River Silica (%=3.3) and Knife River Flint (%=3.3). The upper component also includes a greater diversity of raw materials, although the sample size is much smaller.

A second example comes from 32RI785, in the southeastern corner of North Dakota. In excavation block 8, the investigators identified three components: Middle Plains Archaic (McKean Complex), Late to Middle Plains Archaic, and Late Plains Archaic (Dobbs 2000). The components show a clear decline in the prominence of SRC (%=51.0 to 45.0 to 20.9) and an increase in the importance of KRF (%=16.8 to 27.7 to 56.0); obsidian also appears in the latest component (%=0.7).

A third example comes from the King Coulee site (Appendix 2: 21WB56), along the Mississippi River in southeastern Minnesota (Perkl 1996, 2002). Excavation at this site sampled the upper 170 cm of a very deep artifact-bearing sediment column in a depositional environment. It appears that the entire 170 cm either represents ceramic components or contains elements of ceramic components, based on the distributions of sherds. Test Units 1 and 2 yielded a rich sample of artifacts, with radiocarbon dates of 1940 ± 70 at 75-80 cm, and 2320 ± 70 at 125-130 cm. The lithic assemblage from these two units shows initial dominance by Hixton Quartzite (%=40.0), along with significant amounts of quartz (%=10.0). Above this, Hixton and quartz both diminish, and Prairie du Chien Chert strongly dominates the sample (average %=84.4). With time, although PdC remains important it gradually decreases in prominence (%=77.5 to 68.1), while quartz again becomes important near the top of the sampled column (%=12.3) as does PdC (%=87.0).

A final example comes from the Cherokee site (13CK405) in northwestern Iowa. At this site, the investigators found clearly stratified Late Paleoindian, Early Archaic and Middle Archaic components (Anderson 1980; Anderson and Semken 1980). The raw material profiles from Cherokee are incomplete; many of the currently-used raw material types had not been specifically defined, so the investigators used descriptive categories instead that cannot be easily matched with currently-used types. The site nonetheless provides some useful lithic data that reveals some interesting trends. The Late Paleoindian component (ca. 8400 BP) includes 19.5 percent Tongue River Silica, a low-quality but locally-abundant raw

Figure 4-2. Configuration of utility sectors in the utility plane.



	Superior	Good	Average	Marginal	Sub-marginal
Boulder	**UP-1 Sector**				
Boulder-Cobble					
Cobble	**UP-2 Sector**				**Chopper Sector**
Cobble-Pebble	**UP-3 Sector**				
Pebble					***Indet. size, quality***

material, and 5.0 percent of Fusilinid Group cherts, which have their closest source in southwestern Iowa. In the Early Archaic component (ca. 7200 BP), the importance of TRS soars to 89.7 percent, while Fusilinid Group cherts comprise only 0.2 percent of the assemblage. And in the Middle Archaic component (ca. 6350 BP), TRS falls to a scant 0.7 percent, while Fusilinid Group cherts comprise a full 50.0 percent.

Here we have four multicomponent sites that have a degree of temporal overlap. Various local and nonlocal materials appear to wax and wane in relative importance. But it is not immediately clear what drives these changes, and how the changes might be related between sites much less regions. We might posit that local raw material access remains relatively stable at each site, so the changes in raw material composition reflects some kind of deliberate changes in selection of raw materials or availability of nonlocal materials. And again, what is driving these changes and are the same factors at work in different regions?

To make some progress in answering questions like these, it seems that we need a way to look past tallies of individual raw materials and instead start looking at more abstract raw

Table 4-1. Geological system and nomenclature for defining the size of sedimentary clasts (Udden 1914; Wentworth 1922).

Size Grade	Size Range	Notes
Boulder	> 256 mm	--
Cobble	64 - 256 mm	--
Pebble	32 - 64 mm	Also called very coarse gravel; smaller size ranges in the pebble category are not included.

material characteristics. Undoubtedly there are various ways we could try to accomplish this. I would like to propose one particular approach, an approach which I think can give us a fresh perspective and useful way to think about lithic raw materials and their use.

Essential Raw Material Characteristics

One of the first stages in addressing the problem is to decide which raw material characteristics are most important for understanding raw material use. There is not a stock answer to that question, and in fact there is probably no single answer. The list of relevant characteristics may well depend on where in the world you look or what questions you ask.

We could use many different characteristics to describe and distinguish lithic raw materials. Some are intrinsic to the stone (e.g., color, inclusions, texture, homogeneity), while others describe extrinsic factors (e.g., distribution, abundance). Wilson (2007:338), for example, provides a helpful literature review on this topic, and notes that

> many factors can have entered into a person's choice to use one source rather than another. Those factors can be grouped into two categories, the geologic/geographic characteristics of the source itself (quality, abundance, size of pieces, etc.), and the human factors (direction of travel, time available, social restrictions, etc.).

For her research, she settles on a larger set of characteristics than I use in this thesis. In part this is because some of the factors Wilson names (and uses in her analysis) are accounted for here in the geographic resource model. In addition, one of the goals (and challenges) of the current research has been to produce a functional model with the smallest possible number of raw material characteristics.

A number of researchers have focused on quality, size and availability (or something essentially similar) as central characteristics in understanding raw material use. Andrefsky (1994a), for example, makes the useful point we cannot adequately understand lithic technological systems without considering raw material quality, size, shape and availability. In a regional example, Gregg (1987a:370) discusses the availability of Knife River Flint in the northeastern plains outside of the primary source area in west-central North Dakota. He notes that "Quantitative data regarding *size, quality, and abundance* [emphasis added] will need to be collected and analyzed in order to objectively evaluate the potential significance of this resource." Many other examples could be cited.

My own current list of essential raw material characteristics includes three items: flaking quality, package size and availability. It may be that as raw material use is explored further, other factors will have to be considered in order to better account for observed patterning in raw material use. I propose, however, that these characteristics account at some essential level for how ancient flintknappers organized raw material procurement, raw material use, and the overall lithic economy.

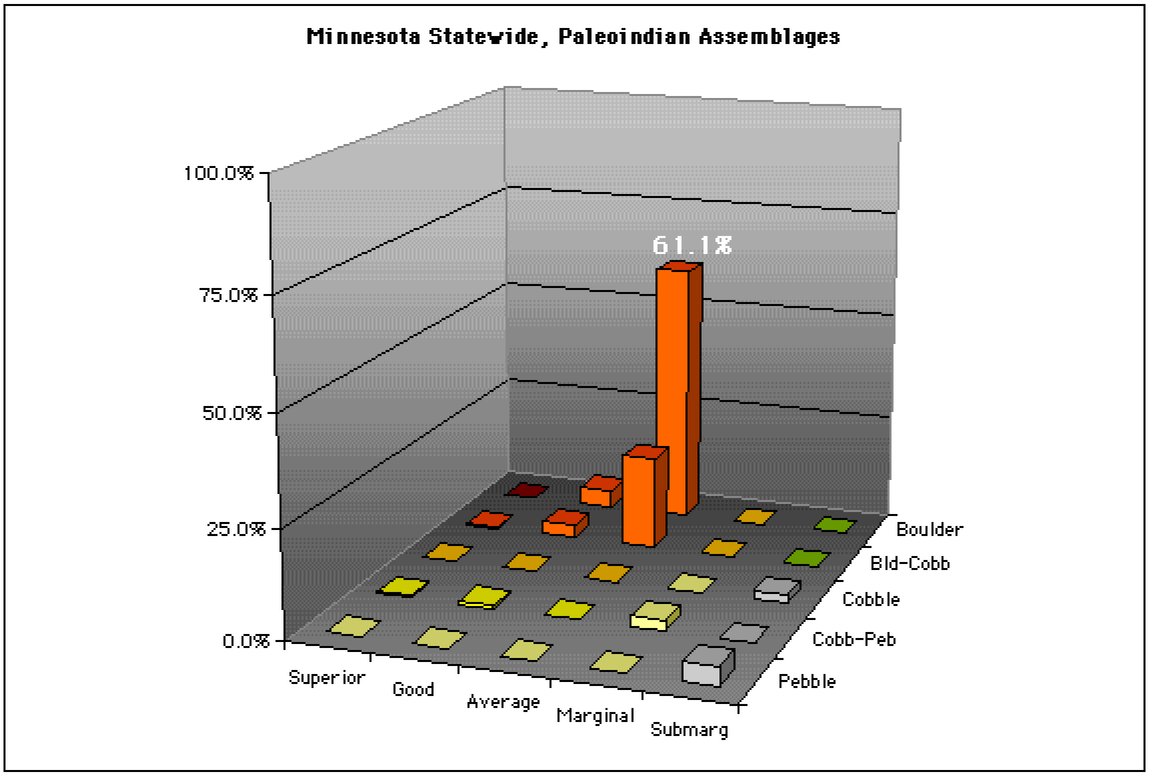
Flaking quality seems to be important because it affects how easily a flintknapper can shape a material, and beyond that the suitability of the material for the kinds of use associated with certain tool types. Regionally, for example, end scrapers tend to be made of the finer-grain, better-quality materials, possibly because of the need to carefully control the shape of the working edge.

Package size is important because different reduction strategies and tool types require raw material stock of different size. By way of example, large bifaces (e.g., Paleoindian lanceolate points) can only be made from large pieces of raw material, whereas very small bifaces (e.g., small triangular Woodland points) can be made from large or small pieces. Given effectively endless supplies of large pieces of raw material, the point would be moot. Given limited supplies, however, the point becomes quite important.

This introduces the importance of availability. Again, given effectively endless supplies of good-quality, large-package-size raw material, the point would be moot. Regionally, the supplies of either good-quality or large-package-size raw materials are limited, and a substantial part of the available toolstone meets neither of these criteria. Thus availability becomes an important criterion in strategies of how raw materials are procured and used.

Each of these items is introduced here, then further explored as the discussion continues.

Figure 4-3. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data, Minnesota statewide.

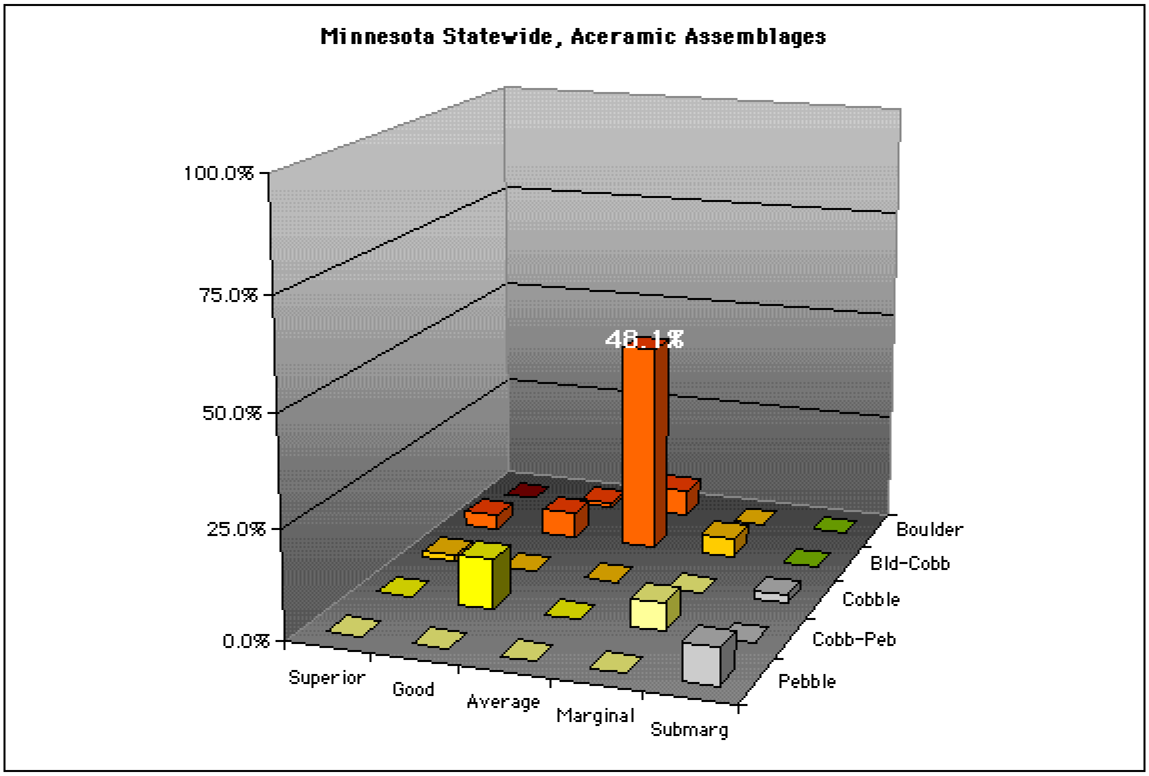


Flaking Quality

Quality is generally defined here as the degree to which a raw material can be flaked in a predictable, controlled fashion. In other words, in some lithic utopia the best quality raw material would fracture exactly as the flintknapper wanted it to. In addition, this material would produce a durable tool with a strong edge. A high quality raw material would be perfectly homogenous, perfectly isotropic, and neither too brittle nor too tough. Knife River Flint comes to mind; Tongue River Silica does not.

As a material becomes less homogenous, less isotropic, and either too tough or too brittle, the overall flaking quality diminishes. Most quartz, for example, is not especially isotropic; the fracture tends to follow crystal orientations and propagate in unpredictable directions. Many pieces of Red River Chert change texture from one end to another or contain fossil casts; these inhomogeneities also deflect fractures. Swan River Flint is

Figure 4-4. Utility analysis XYZ depiction of aggregated aceramic assemblage data, Minnesota statewide.



extremely tough; while it produces durable tools, fracture initiation is difficult and the extra force required can make fracture control more difficult.

There are clearly deficiencies in this definition, but nonetheless it may be well suited to the current problem. Further elaboration of the definition might or might not be of any value to examining raw material use. It is also worth bearing in mind that "quality" may be the third rail of lithic studies. Despite the efforts of many capable researchers (e.g., Brantingham et al. 2000; Braun et al. 2009; Brown et al. 2009; Luedtke 1992; Noll 2000; Woods 2010), we do not have a standard way to describe or compare flaking quality or the workability of various toolstones. This is in spite of the fact that it is not difficult to build an intuitive sense of relative quality, as any flintknapper can tell you. Since there is no standard method for handling the topic, we will have to make do with a working definition tailored to the particular research at hand.

That being said, this discussion must include a few caveats. First, when we think of a particular raw material we tend to think of a particular level of quality – as if every piece of that material was equal in quality. This is patently not the case, and any raw material will vary in relative quality from piece to piece or even within a single piece. What we think of as the general quality of that raw material might be the flakeability of the better pieces, or possibly the most common quality level. For many purposes it is probably not especially important to consider the issues of variable quality, especially since it appears that flintknappers routinely tested pieces of potential toolstone and discarded the poorer pieces. This effectively reduces the range of quality that we encounter in archaeological sites. Range of quality does become an issue, however, in some parts of this analysis, so it seems advisable to introduce the issue here.

Second, quality can only properly be defined in terms of certain reduction techniques, strategies, and intended end products. A raw material that is well suited to making an adze, for example, might be poorly suited to making an end scraper. We will, however, ignore this for the time being but revisit it as the discussion progresses. We can do this because most of the lithic reduction seen at sites in the region seem to depend on only a few reduction techniques and strategies. There are few "industries" that depend on different reduction techniques, and we can address these specifically as they arise.

Third, in laying out the model we can estimate the relative quality of regional raw materials (or the quality range) based on observation of artifacts and on experimental flintknapping. These estimates might be quite adequate for some of the better known raw materials, but less adequate for other materials. A better evaluation of the flaking characteristics of regional materials would be a valuable contribution to regional archaeology, and a very helpful step in testing or refining the use pattern model presented here.

Package Size

While absolute size (measured length, width and thickness) would be useful in examining raw material use patterns, package size is perhaps more useful. Previous researchers have used this concept to incorporate not only absolute, measured size, but also the configuration of a piece of raw material (e.g., Bradbury and Franklin 2000:44; Dibble et al. 2005; Rasic and Andrefsky 2001). This acknowledges the effect that clast shape can have on the effective size of a piece of raw material. For example, a hemispherical piece of raw material would probably be split in order to produce an edge with a suitable angle for knapping. The splitting reduces the effective size of the piece before the main reduction sequence begins. A more

Table 4-2. Summary of estimated flaking quality, package size, and abundance for lithic raw materials found in Minnesota or commonly occurring at archaeological sites.

	Flaking Quality	**Package Size**	**Abundance**
South Agassiz Region			
Knife River Flint (local)	Marginal ?	Pebble ca. 5 cm (sec)	Rare
silicified wood	Undetermined	Pebble ca. 5 cm (sec)	Rare
Swan River Chert	Average ? (with heat treatment)	Boulder-cobble ca. 75 cm (pri) ca. 25 cm (sec)	Common
Red River Chert	Good ?	Pebble ca. 5 cm (sec)	Common
West Superior Region			
Fat Rock Quartz	Average	Cobble ca. 15-20 cm ? (pri)	Abundant near restricted source
Lake Superior Agate	Average to marginal ?	Pebble ca. 3-5 cm (sec)	Occasional ?
Hudson Bay Lowland Chert	Superior ?	Indeterminate in study area	Indeterminate in study area
Gunflint Silica	Good ?	Pebble-cobble ?	Common ?
Biwabik Silica	Good ?	Pebble-cobble ?	Occasional ?
Jasper Taconite	Good ?	ca. 30 cm ? (pri) ca. 10 cm (sec)	Common ?
Kakabeka Chert	Good	Cobble ?	Abundant ?
Pipestone Region			
Gulseth Silica	Undetermined	Undetermined	Undetermined
Hollandale Region			
Prairie du Chien Chert	Average	Boulder-cobble ca. 20-30 cm (pri)	Abundant
Cedar Valley Chert	Good (superior?)	Boulder 30 cm plus (pri)	Abundant in restricted areas ?
Galena Chert	Good	Boulder ca. 10 x 30 cm (pri)	Abundant in restricted areas ?
Grand Meadow Chert	Good (to superior?)	Cobble ? ca. 10-15 cm (pri)	Abundant in restricted source area
Shell Rock Chert	Good	Cobble ca. 10-12 cm	Abundant at a single location
Maquoketa Chert	Submarginal	Cobble ca. 10-15 cm	Abundant in restricted areas ?

Table 4-2. Summary of estimated flaking quality, package size, and abundance for lithic raw materials found in Minnesota or commonly occurring at archaeological sites.

	Flaking Quality	**Package Size**	**Abundance**
Border Lakes Greenstone Group			
Knife Lake Siltstone	Superior (pri) Marginal (sec)	Up to 1 m (pri) ca. 25-30 cm (sec)	Abundant (pri) Occasional ? (sec)
Lake of the Woods Siltstone	Average ?	Boulder (pri) ca 10-15 cm (sec)	Abundant ? (pri) Rare ? (sec)
Lake of the Woods Rhyolite	Average ?	Boulder (pri) ca 10-15 cm (sec)	Abundant ? (pri) Rare ? (sec)
Tongue River Silica			
	Marginal (with heat treatment)	Boulder (sec, old tills) Cobble (sec, new tills)	Abundant ? (old tills) Occasional ? (new tills)
Western River Gravels Group			
	Average to high ?	Pebble ca. 3-5 cm (sec)	Occasional
Sioux Quartzite Group			
Sioux Quartzite	Submarginal	Boulder-cobble ? (sec)	Undetermined
Sioux Conglomerate materials	Average to marginal ?	Pebble to cobble	Limited at restricted source areas
Generic Raw Materials			
quartz	Marginal to submarginal	Pebble (widespread) Cobble (locally)	
quartzite	Marginal to submarginal	Cobble	
basaltic rock	Submarginal	Cobble	
granitic rock	Submarginal	Cobble	
rhyolite	Undetermined	Undetermined	
Major Exotics			
Knife River Flint	Superior	Up to 40-plus cm ca. 15 cm (more common)	
Hixton Group	Good	1 m plus	
Burlington Chert	Good to superior	30-plus cm	
Obsidian	Superior	Boulder	
Other Nonlocal Materials			
Fusilinid Group	Good	ca. 15-20 cm	Undetermined
Maynes Creek Chert	Good (with heat treatment)	Up to 30 cm	Undetermined

(pri) = associated with primary geologic source (sec) = associated with secondary geologic source tabular piece of raw material, in contrast, may present edges with suitable angles. The effective size of the piece does not have to be reduced before the main reduction sequence begins.

That said, package size is not explicitly defined here. Rather its use serves as an acknowledgement that the shape of a piece of raw material is an important consideration, and use of the term also allows size and shape to be considered as a single term in the analysis. In support of use of the term package size, a review of descriptive information for each raw material (Chapter 3) includes available observations on clast shape.

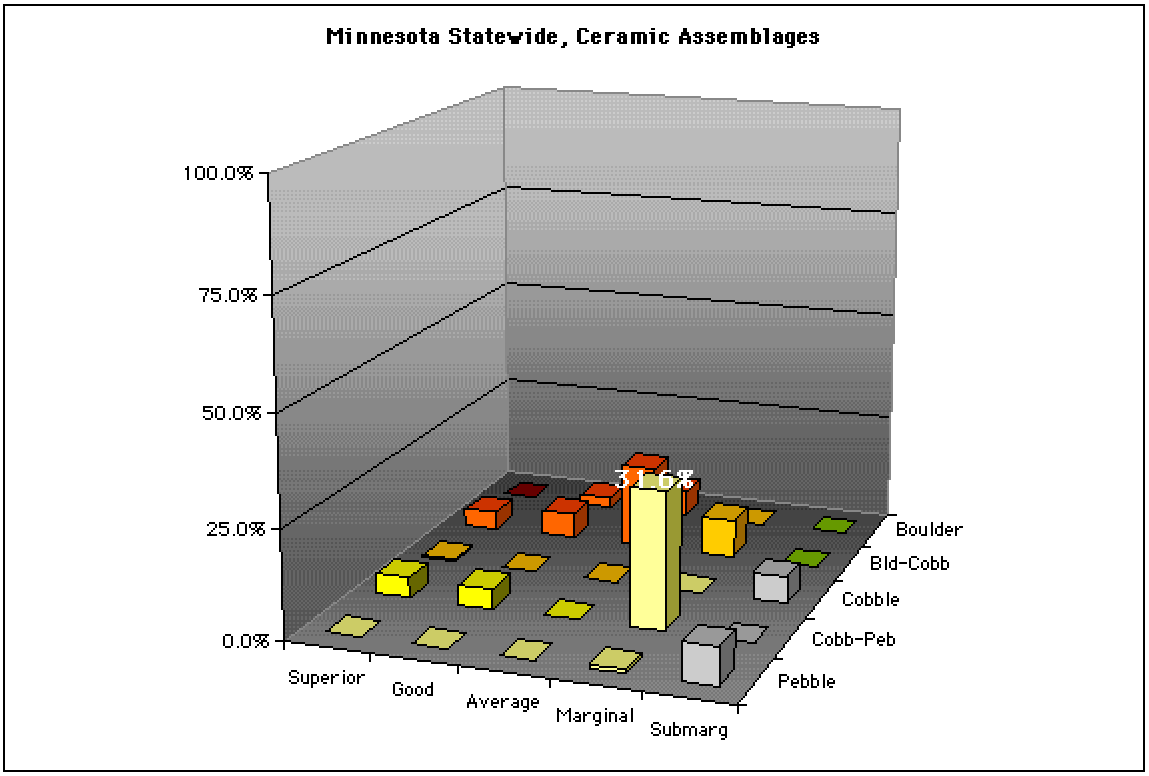
The available descriptive information varies in completeness and detail from one raw material to another. For size, some sources include specific measurements, some include only general observations by categories like pebble and cobble, and some include no information. For this and other reasons, it seemed prudent to frame the analysis in terms of size categories instead of absolute size. Geologists provide a useful scale for discussing the relative size of clasts and particles, and that scale seems to be well suited to this analysis (Table 4-1). Note that the scale also covers finer sediments such as sand, silt and clay. For the discussion of pieces of toolstone, however, the relevant terms are boulder, cobble and pebble. These terms, sometimes with the qualifiers "large" and "small" (as in "small boulder" or "large cobble"), will be used throughout this discussion.

Anyone who has gathered raw material samples can point out that a given raw material occurs in pieces of many different sizes (which calls to mind the previous discussion of a range of quality in a given raw material). This is certainly true, and something we must keep in mind as we work with the use pattern model. In fact it would be helpful to have better information on the distribution of clast sizes for each regional raw material. In the absence of such information, however, we can focus on two aspects of size: the largest size available for a given raw material, based on observations to date, and especially the largest size *commonly* available for a given raw material.

Availability and Intensity of Use

Availability refers to the amount of a given raw material that could be obtained by a group, given their access to raw material sources or source regions, their access to nonlocal materials obtained second hand, and practical limits to the time and effort available for procuring toolstone. This can be distinguished from abundance, which is a property of the underlying resource base. Abundance, for example, would refer to how much Swan River Chert was

Figure 4-5. Utility analysis XYZ depiction of aggregated ceramic assemblage data, Minnesota statewide.



present in a given area, in terms of objective measures like weight or number of clasts. The discussion of raw materials in Chapter 3 attempted to address relative abundance, while admitting that we have only incomplete (and not entirely comparable) information. Availability, in contrast, is an aspect of a raw material economy – how much of the resource base was actual available for use, given the kinds of considerations listed above.

In practice the idea of availability is – at least for the moment – an analytical convenience. In the first place, what units would we use to measure such availability – number of pieces, volume, weight, yield in working edge? In the second place, we do not currently know enough about factors like territory, extraction methods, or exchange systems to begin to sort this out effectively. The concept, however, is still useful. There is a finite abundance of flakeable toolstone in existence, and only a portion of that is available at any given time or place. What that amount was would depend on factors like territory, exchange systems, extraction methods, available time and energy, and so on. Methods like quarrying might increase the harvest of raw material, but at some point limits on time, territorial access, exchange systems, and so on would effectively put a limit on how much raw material could be procured.

So although we might not know what the limit was, we can say that there was a limit. And in one sense, it is not as important to know what the limit was in a quantitative sense as to know that there was a limit. In fact this plays an important role in development of a use pattern model. This should become clearer as the discussion progresses.

The decision to view availability as an unknown quantity and an analytical convenience leaves something of a gap in terms of the practical application of these ideas to raw material analysis. We can, however, fill this gap by using a proxy for availability. We can call this proxy intensity of use. Intensity of use is derived from actual lithic data, and is expressed in terms of percentage of a total lithic assemblage. For example, in the case of the Greenbush Borrow Pit site referenced above, Swan River Chert constituted 87.0 percent of the total lithic assemblage. Thus 87.0 percent is the intensity of use of SRC at the Greenbush Borrow Pit site. Presumably this figure represents a practical solution on the part of the flintknappers to balance, in terms that were meaningful to them, such factors as total abundance of various raw materials, territorial access, extraction methods, and exchange systems. Since both availability and abundance remain elusive but intensity of use pervades the data, the remainder of the discussion references intensity of use with the understanding that this is related to availability in ways that we can hope to better understand in the future.

Narrowing our list of essential characteristics to flaking quality, package size, and intensity of use gives us a starting point for thinking about raw material use. The second step is to think about how we can actually use this approach, practically speaking. How can we examine the interaction of quality, size, and intensity of use, and how can we depict this? In working with these ideas and also in looking at regional lithic data, I have found it helpful to use a graph. The following section examines how we might use the conventions of a three-dimensional (XYZ) graph to frame a way of exploring these ideas.

The Elements of a Graphic Conceptual Space

I have proposed that three characteristics might prove critical in understanding how regional lithic raw materials were used. It seems potentially helpful to have a way to depict the interaction of these characteristics, and so to illustrate our discussion. Since we are looking at three terms, a three-dimensional graph might provide a useful way of exploring this idea, with

Table 4-3. Initial placement of regionally occurring raw materials in the utility plane.

	Superior	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder	obsidian	Jasper Taconite	Knife Lake Siltstone Lake of the Woods Siltstone Lake of the Woods Rhyolite indeterminate BLG Group Hixton Group		
Boulder-Cobble	Burlington Chert Knife River Flint	Biwabik Silica Gunflint Silica Kakabeka Chert Other Animikie Group Cedar Valley Chert Galena Chert Maynes Creek Chert	Swan River Chert Prairie du Chien Chert	Tongue River Silica	Sioux Quartzite
Cobble	Grand Meadow Chert	Shell Rock Chert Fusilinid Group	Fat Rock Quartz		Maquoketa Chert basaltic rock granitic rock other chopper materials
Cobble-Pebble	Hudson Bay Lowland Chert	Red River Chert		Misc. quartz	
Pebble		Knife River Flint (local)	silicified wood WRG Group	Lake Superior Agate	

BLG = Border Lakes Greenstone WRG = Western River Gravels

the three terms displayed along the three axes of the graph. In fact I have found that this approach works well, and I will use it in the following discussion not only to depict somewhat abstract ideas but also to display lithic data.

Figure 4-1 illustrates this graph. The three factors – quality, size, intensity of use – each occupy one axis of the graph. Note that what looks like a conventional graph is, in a sense, the use of graphing conventions to create what we might call a "conceptual space." It is a conceptual framework for depicting a set of ideas, and a way to see the interaction of different parts of a system – in this case a raw material economy. Also note that the X and

Y axes of the graph are only nominally demarcated in quantitative scales. At some points, given the proper data, these axes could be adjusted and calibrated with more precise quantitative scales.

To develop the conceptual space and facilitate discussion, we can also put names on some other elements. These are introduced and explained below.

The Utility Plane: Flaking Quality vs. Package Size

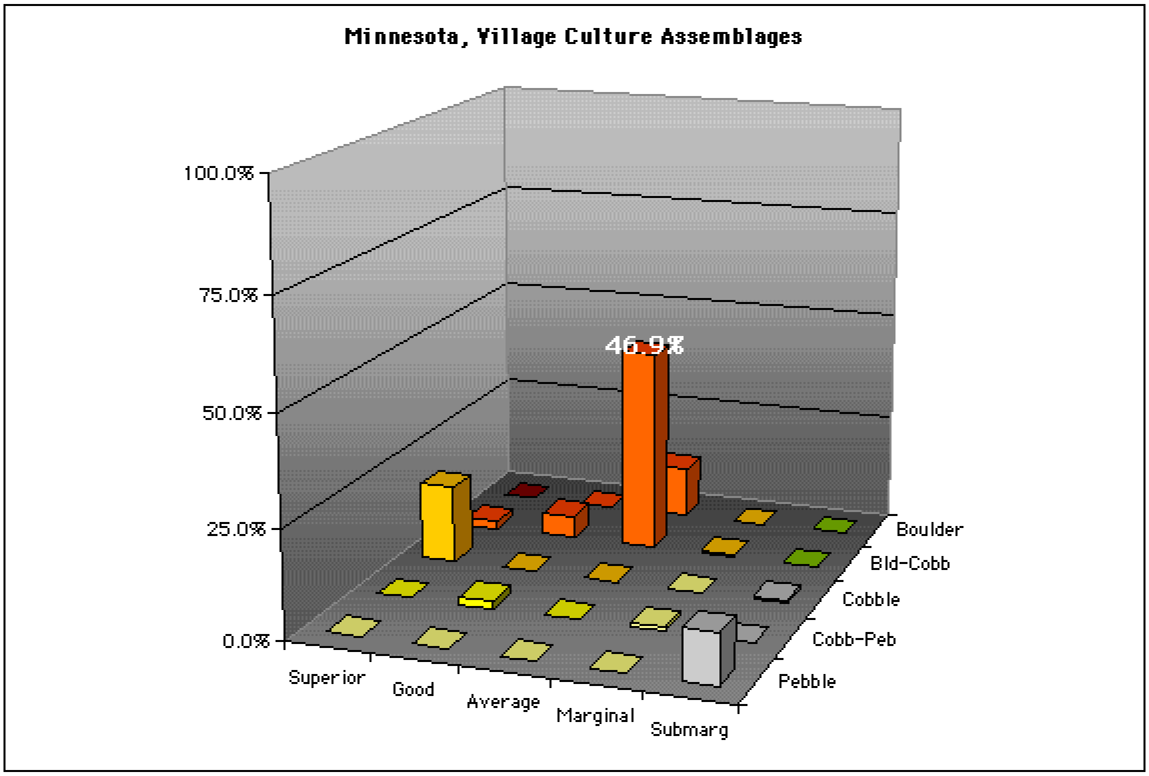
Before we try to handle all three dimensions, we can begin with just the X and Y axes. Imagine a graph where the X axis represents relative flaking quality, ranging from very high quality at the 0 point along the axis to submarginal quality at the farthest point along that axis. Now imagine that the Y axis represents prevailing size of available pieces, ranging from large boulders at the 0 point along the axis to pebbles at the farthest point along that axis. If we had a way at this time to quantitatively measure flaking quality and package size, we could demarcate these axes with the appropriate numerical scales. Since we do not, however, each axis is demarcated with a series of relative and mutually exclusive categories.

This defines a plane where the most desirable raw materials are in the 0,0 corner and the least desirable materials are in the opposite corner (Figure 4-1). For the sake of reference we can call this matrix the "utility plane." This term is chosen to reflect the expectation that the combination of flaking quality and package size is important in determining the potential usefulness – the utility – of a raw material.

Since each axis is divided into a number of categories, the utility plane is naturally divided into a number of squares or cells. Each cell represents a different combination of flaking quality and package size. On this utility plane, therefore, each raw material that was used in the region (whether local or extralocal) can be placed in the cell that best reflects its relative flaking quality and common package size. This placement reflects our best current knowledge of the characteristics of regional raw materials, including both first-hand knowledge and clues gleaned from other investigators. This information was reviewed above (Chapter 3), and is summarized in Table 4-2. The proposed placement of raw materials is undertaken in the next section, following this introduction to the conceptual space.

When it comes to looking at and discussing actual lithic data in the utility plane, it helps to be able to discuss parts of the utility plane that are larger than individual cells. We can call these areas utility sectors. Figure 4-2 shows these sectors. The sectors that figure most in discussion are called UP-1, UP-2, UP-3 (with UP standing for utility plane). The chopper

Figure 4-6. Utility analysis XYZ depiction of aggregated village culture assemblage data, Minnesota statewide.

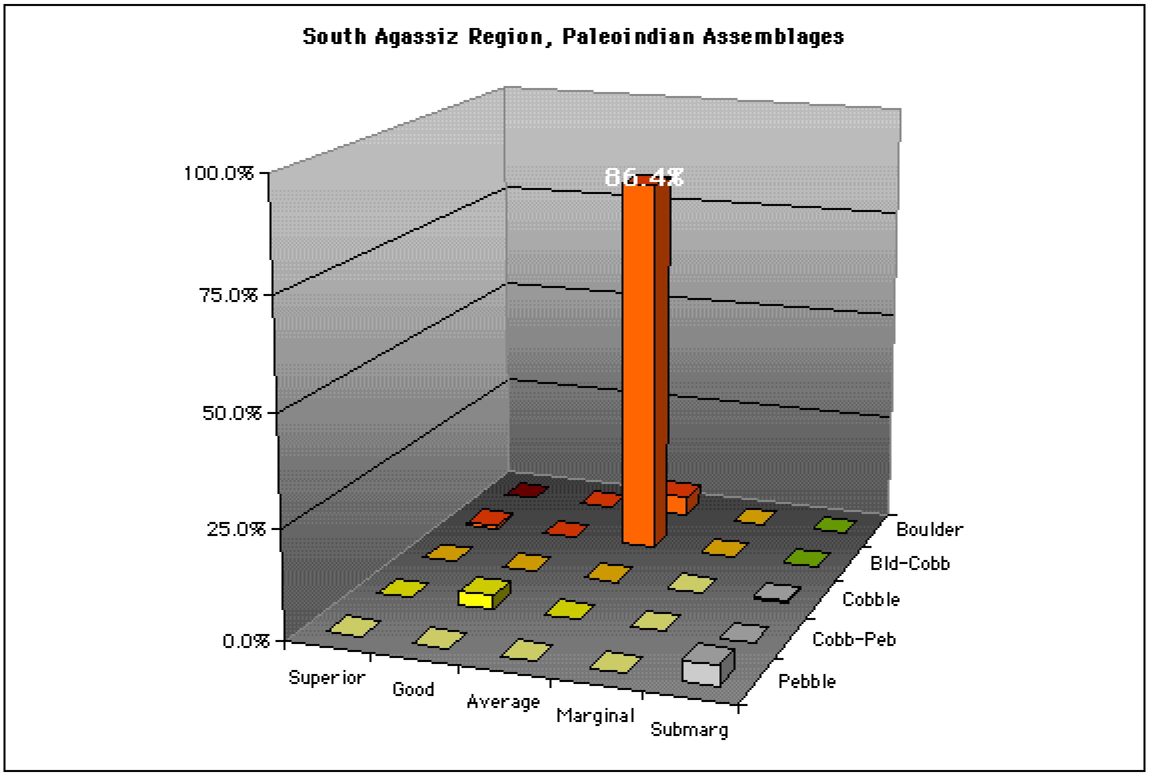


sector (here a single cell) reflects use of submarginal quality cobbles for production of choppers. Note also that the single cell at the intersection of submarginal quality and pebble size is labeled "Indeterminate size, quality." It appears that there was little use of submarginal-quality pebbles, which is hardly surprising. Conveniently enough, this leaves a free space in the utility plane which can be used for displaying a different set of data. Most assemblages include raw materials that cannot be located in the utility plane in terms of flaking quality and package size. Generically identified raw materials provide a good example. It is still important, however, to account for and display these materials as a component of the assemblage. The submarginal-quality pebble cell provides a space for this display.

The Centrum: An Ideal Raw Material

For the sake of reference, we can call the 0,0 point in this graph the "centrum." The centrum represents a hypothetical ideal raw material. This raw material is perfectly

Figure 4-7. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the South Agassiz Resource Region.



isotropic, perfectly homogenous, and is neither too brittle nor too tough; in addition, it can be had in any size piece needed for a given use. As we move away from this centrum in any direction, the raw materials become less desirable. They may be of increasingly poorer flaking quality, or increasingly smaller package size, or both.

If we begin near the centrum, we can again use Knife River Flint as an example. It exhibits high flaking quality and is available in pieces as large as boulders. Knife River Flint is thus a very desirable raw material for making all sorts of flaked stone tools, large and small, and it is located relatively close to the centrum. As we move away from the centrum along the X axis, we encounter a series of raw materials that also are available in pieces as large as boulders. Each successive material, however, is of generally poorer flaking quality. Swan River Chert, for example, would lie near the X axis but farther from the centrum, since it is plainly less flakeable than KRF. Sioux Quartzite, available in large but nearly unflakeable pieces, would lie still farther out on the X axis.

Table 4-4. Intensity of use for selected lithic raw materials for ceramic assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Ceramic Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
South Agassiz Materials	**19.3**	**52.0**	**11.5**		**8.0**
Red River Chert	4.6	15.9	1.9		1.6
Silicified Wood	-	0.1	-		0.1
Swan River Chert	14.7	36.0	9.6		6.3
West Superior Materials	**11.4**	**1.4**	**9.9**		**1.2**
Animikie Group (*not specified*)	0.1	-	0.2		0.1
- Biwabik Silica	-	-	-		-
- Gunflint Silica	3.3	0.4	3.0		0.2
- Jasper Taconite	2.2	0.2	2.7		0.1
- Kakabeka Chert	0.1	-	0.1		-
Fat Rock Quartz					
Hudson Bay Lowland Chert	4.7	0.5	2.5		0.5
Lake Superior Agate	1.0	0.3	1.5		0.2
Pipestone Materials	**-**	**-**	**-**		**-**
Hollandale Materials	**7.9**	**3.0**	**2.5**		**72.4**
Cedar Valley Chert	0.6	0.1	0.2		4.8
Galena Chert	2.0	0.2	0.1		26.4
Grand Meadow Chert	0.6	0.6	0.1		5.6
Prairie du Chien Chert	4.8	2.0	2.1		35.5
Shell Rock Chert	-	-	-		0.1
Tongue River Silica	**9.1**	**6.0**	**12.4**		**0.9**
Border Lakes Greenstone Group	**5.7**	**3.4**	**5.9**		**0.9**
Knife Lake Siltstone	3.3	1.2	4.3		0.5
Lake of the Woods Siltstone	0.1	0.5	-		-
Lake of the Woods Rhyolite	2.3	1.7	1.6		0.4
Sioux Quartzite Group	**-**	**-**	**-**		**-**
Western River Gravels Group	**0.2**	**0.2**	**0.1**		**-**
Quartz *(not specified)*	**31.6**	**10.8**	**44.2**		**4.1**
Other *(cf. chopping tool matls)*	**1.5**	**1.1**	**1.6**		**0.3**

Table 4-4. Intensity of use for selected lithic raw materials for ceramic assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Ceramic Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
Generic Identifications	**8.7**	**12.4**	**8.4**		**8.5**
Exotic Materials	**4.7**	**9.7**	**3.5**		**3.7**
Burlington Chert	0.4	0.2	0.4		0.5
Hixton Group	0.4	-	0.4		2.3
Knife River Flint	3.8	9.2	2.6		0.4
Obsidian	0.10	0.15	0.12		-
Other Nonlocal Materials	**-**	**0.1**	**-**		**0.1**
Fusilinid Group					
Maynes Creek Chert					
Sample Size	*53,954*	*10,506*	*33,314*	*0*	*3,819*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample. The "Minn Statewide" column includes data from counties that lie in more than one resource region; these counties are not included in the regional columns.

In contrast, if we again begin with KRF near the centrum but move out along the Y axis, we encounter a series of highly flakeable raw materials in ever-smaller packages. Grand Meadow Chert should lie near this axis but farther from the centrum, since it has good flaking characteristics but is generally not found in pieces larger than midsized cobbles. Farther along the Y axis we would find some of the chalcedonies and jaspers that belong to the Western River Gravels Group. These materials are highly flakeable, but are only found as packages the size of pebbles.

In the corner opposite of (and farthest from) the centrum we would find pebbles of submarginal flaking quality. These certainly occur in the region. However, it is unlikely that prehistoric populations used such materials to any noticeable degree and therefore modern researchers have not paid any particular attention to these materials.

The Z Dimension: Intensity of Use

The utility plane matrix gives us a place to start thinking about issues in raw material use, and can serve as the foundation of our raw material analysis. To develop a more complete analysis, however, we need to add a third dimension to our conceptual space. This is the Z axis, which is associated with quantities of raw material. With the addition of this axis the X axis (quality) lies to the right, the Y axis (size) to the left, and the Z axis (quantity) is oriented up and down (Figure 4-1).

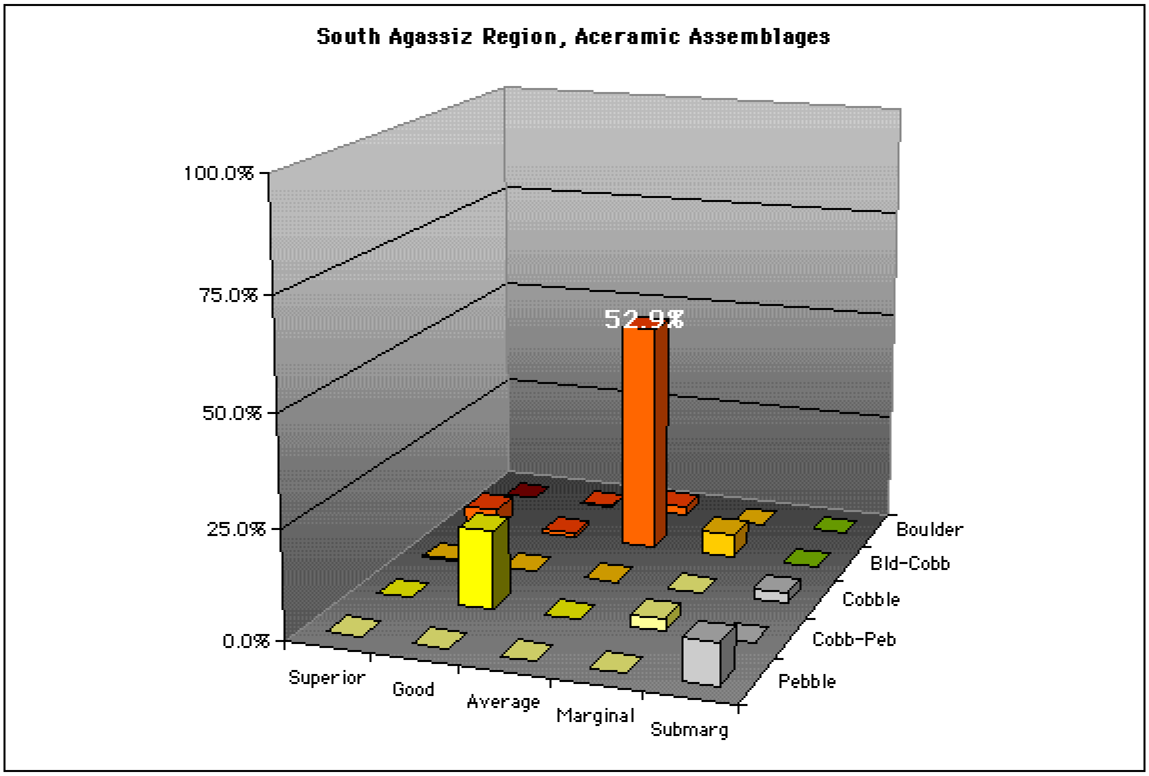
We can label the Z axis as 0 percent at the utility plane, and 100 percent at some convenient distance up from the utility plane. In a purely conceptual sense, the percentage would indicate how much of the (hypothetical and unknown) available supply of a raw material is being used – ranging from none to all. In practice, however, the Z axis is used to display intensity of use as a proxy for availability. You will recall that intensity of use is derived from the lithic data, and is expressed as a percentage. Since the Z axis expresses percentage, and since raw material analyses are routinely expressed as percentages, it is fairly simple to use the conceptual space to depict intensity of use and actual lithic data. For each cell in the utility plane we can display a column, with the height of the column indicating the percentage of the assemblage that falls within that cell.

Rehearsing the Conceptual Space: A Hypothetical Scenario

Before we use this conceptual space to look at actual raw material use in the region, we can use the space to look at a hypothetical scenario in order to become more familiar with the conceptual space as a tool and to illustrate some specific elements of lithic technology that can be accounted for using this tool. For the sake of simplicity, this illustration emphasizes a situation driven by supply and demand; in reality, many factors would likely drive changes in raw material use. Note that in the following scenario there are no underlying quantitative data, and that as a convenience the discussion of the Z axis focuses on hypothetical availability (where discussion of actual data will focus on intensity of use).

Imagine a small population with a fairly focused lithic technology. They make large bifaces that serve multiple functions, including serving as cores to provide flake tools. This "Population 1" initially makes use of the best available raw material, "Flint A," which is of superior flaking quality, commonly occurs as boulders, and is thus found in the utility plane near the centrum (the hypothetical ideal raw material). Because the population is small, they

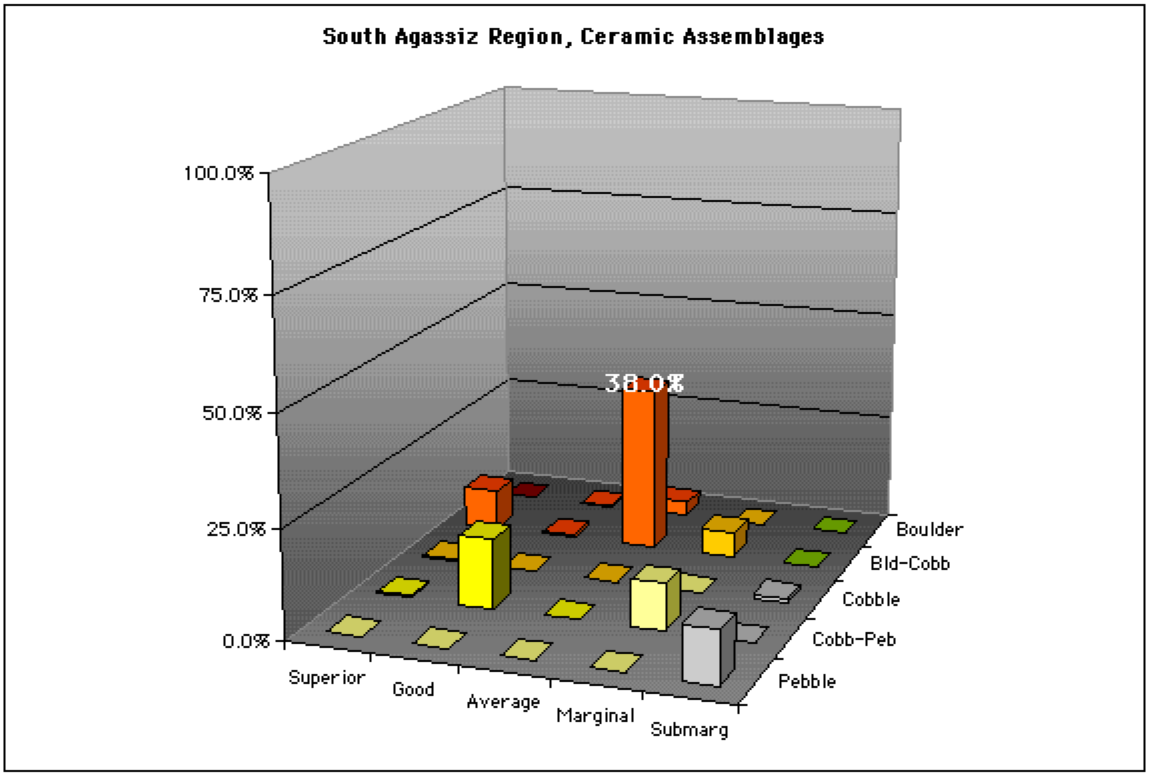
Figure 4-8. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the South Agassiz Resource Region.



use only part of the available supply. We can depict this situation in our conceptual space with a single column in the utility plane cell closest to the centrum (and within utility sector UP-1), and the column rises only part way up the Z (intensity of use) axis.

As time goes by, the population grows and so does the demand for Flint A. In our depiction, the column gradually rises towards the 100 percent point on the Z axis. At some point the column reaches 100 percent; in other words, the population is using all of Flint A that they can procure. At this point some change or correction is required. Population 1 has various options, some of which might include 1) stopping population growth to prevent further demand on Flint A resources; 2) augmenting their supplies of Flint A, if this is possible, by some action like increasing their provisioning territory; 3) supplementing their supplies of Flint A with another raw material with similar characteristics, possibly obtained through trade; 4) supplementing their supplies of Flint A by altering the flaking characteristics of another available raw material, or more specifically enhancing the

Figure 4-9. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the South Agassiz Resource Region.



flakeability of another raw material using heat treatment; or 5) reorganizing their technology to make use of other raw materials that are not as desirable (potentially including nonlithic raw materials, but we will ignore that option in this discussion).

Note how this scenario illustrates the way that the conceptual space can accommodate heat treatment. Heat treatment essentially can be used to move amenable raw materials along the X axis towards the centrum. For the sake of our illustration, however, we will assume that instead of using heat treatment Population 1 opts to reorganize their lithic technology.

Instead of producing large bifaces that act as both tools and flake-cores, Population 1 shifts to producing both smaller bifaces and flake tools directly from the original, first-generation cores. Population 1 has eliminated the intermediate step of making patterned cores, or the customary large bifaces.

In our conceptual space, this means that Population 1 has expanded their provisioning habits to include space in the utility plane farther from the centrum (perhaps into utility sector UP-2). They are still gathering Flint A, represented by a column in the utility plane cell nearest the centrum; but they are also gathering Flints B and C, represented by columns in the cells a step further removed from the centrum. Note that some raw materials are still left unused, namely those in the parts of the utility plane indicating small package size or poorer flaking quality.

This proves to be a successful adaptation on the part of Population 1. They flourish, and the demand increases for Flints B and C (the use of Flint A is already maximized). Eventually all of the available supplies of Flints B and C are also being used. Population 1 again faces the kinds of choices outlined above. This time they use heat treatment on Flint D, successfully increasing the flaking quality of Flint D and moving it along the X axis towards the centrum. Flint D can now be used to support the existing pattern of lithic technology, and crisis is averted.

Eventually, however, Population 2 arrives on the scene. They appropriate part of the territory of Population 1 and cut off access to Flint A and Flint B. Population 1 is once again faced with a set of choices, this time presumably including warfare to re-establish their old territory (including access to Flints A and B, along with other resources). They opt instead, however, to once again reorganize their lithic technology.

This time they adopt a bipolar pebble reduction strategy and to negotiate trading relationships with long-time neighbors Population 3. They use bipolar reduction techniques to produce flake tools from previously unused and unusable raw material stock. They also use the available supplies of Flint C and the exotic material Flint X to support production of small bifaces and other patterned tools.

The utility plane map for this provisioning strategy looks quite different than the utility plane map for Population 1's initial provisioning strategy. The utility plane cell nearest the centrum (Flint A) is no longer occupied by a column, and the remaining columns occupy a broader area located farther away from the centrum (into utility sectors UP-2 and UP-3). And in a sense, the "ceiling" (the height of the Z axis) has been raised by the import of an exotic raw material: the total amount of raw material available in the relevant part of the utility plane has been increased beyond the total availability based only on local supplies.

This hypothetical scenario helps us see how the conceptual space can be used to structure our thinking about how raw material use is organized, and about how this use might change through time and in response to various situations. It also provides some practice in using the conceptual space and in becoming familiar with the associated terminology. And, perhaps not coincidentally, this hypothetical scenario bears some – albeit only some – similarity to the actual scenario that will be proposed for this region.

Locating Raw Materials in the Utility Plane

The next step is to locate individual raw materials in the utility plane based on what we can determine about their general flaking quality and prevailing package size. The availability of the information we need to do this is uneven. We know quite a bit about some raw materials, less or little about others. That said, we can use the available information to attempt a reasonable configuration of the utility plane, with the caveat that this configuration must be improved in the future by additional raw material survey and by experimental flintknapping of regional materials.

The information used for this configuration is reviewed in Chapter 3 and summarized in Table 4-2. This information comes from a variety of sources. Some is published in the standard literature or grey literature, some comes from the informal observations of colleagues, and some comes from personal experience with collecting raw material samples and breaking them into tiny bits.

This discussion includes those raw materials that are known to occur naturally in Minnesota, plus the more common exotic raw materials and a few other, selected nonlocal materials that are found with some regularity at sites in the state. Nonlocal materials are not included if they occur infrequently and only in a small part of the study area (e.g., Fort Union Porcellanite, Moline Chert). These could certainly be added at some point, but because they constitute a small fraction of the lithic record their absence does not significantly affect the outcome of an analysis.

In a discussion of the size of pieces available for any given raw material, it is important to make two points explicit. First, any material comes in a range of sizes. Although this is obvious, the implications may not be. The use pattern model concentrates on the upper end of the commonly available size range. We can probably safely assume that smaller pieces are always available, down to pebbles (noting that pieces smaller than pebbles are not relevant in this analysis). We are probably also safe in assuming that larger than usual pieces are occasionally available for most materials, and that they become ever rarer as the size increases. The distribution of size might be best represented by an S curve on a graph, with highest numbers for small pieces, comparably high numbers for the prevailing package size, and then falling numbers as the curve trails off towards the larger end of the scale. This is

Table 4-5. Intensity of use for selected lithic raw materials for aceramic assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Aceramic Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
South Agassiz Materials	**48.9**	**70.3**	**4.0**		**6.0**
Red River Chert	11.4	18.1	0.5		0.6
Silicified Wood	0.1	0.2	-		-
Swan River Chert	37.3	52.0	3.6		5.4
West Superior Materials	**5.0**	**0.9**	**32.4**		**-**
Animikie Group (*not specified*)	1.3	-	10.9		-
- Biwabik Silica					
- Gunflint Silica	2.0	0.6	13.0		-
- Jasper Taconite	1.0	0.1	4.3		-
- Kakabeka Chert	0.3	-	2.0		-
Fat Rock Quartz					
Hudson Bay Lowland Chert	0.3	0.1	1.9		-
Lake Superior Agate	-	-	0.3		-
Pipestone Materials	**-**	**-**	**-**		**-**
Hollandale Materials	**15.0**	**1.7**	**1.8**		**83.8**
Cedar Valley Chert	1.6	0.2	-		9.2
Galena Chert	1.0	0.2	0.1		5.3
Grand Meadow Chert	1.6	0.4	0.2		9.1
Prairie du Chien Chert	10.8	0.9	1.5		60.3
Shell Rock Chert	-	-	-		-
Tongue River Silica	**4.7**	**5.5**	**10.2**		**0.4**
Border Lakes Greenstone Group	**6.1**	**1.8**	**12.7**		**0.2**
Knife Lake Siltstone	1.5	0.4	7.2		0.2
Lake of the Woods Siltstone	-	0.1	-		-
Lake of the Woods Rhyolite	4.5	1.3	5.5		-
Sioux Quartzite Group	**-**	**-**	**-**		**-**
Western River Gravels Group	**-**	**-**	**-**		**-**
Quartz *(not specified)*	**6.6**	**2.8**	**31.7**		**1.6**
Other *(cf. chopping tool matls)*	**1.9**	**2.4**	**2.1**		**0.1**

Table 4-5. Intensity of use for selected lithic raw materials for aceramic assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Aceramic Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
Generic Identifications	**8.3**	**9.6**	**3.5**		**6.0**
Exotic Materials	**3.6**	**4.9**	**1.5**		**1.6**
Burlington Chert	0.2	0.1	-		1.0
Hixton Quartzite	0.2	0.2	0.3		0.2
Knife River Flint	3.1	4.6	1.2		0.4
Obsidian	-	-	-		-
Other Nonlocal Materials	**0.1**	**0.1**	**-**		**0.2**
Fusilinid Group					
Maynes Creek Chert					
Sample Size	*29,959*	*18,347*	*3,582*	*0*	*4,519*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample. The "Minn Statewide" column includes data from counties that lie in more than one resource region; these counties are not included in the regional columns.

important because a flintknapper would not have rejected a large, high-quality piece of, for example, Lake Superior Agate just because most agates were small and poor quality. We have evidence of this in the form of a Late Paleoindian lanceolate biface made from Lake Superior Agate (Florin 1996), as remarkable as this might seem.

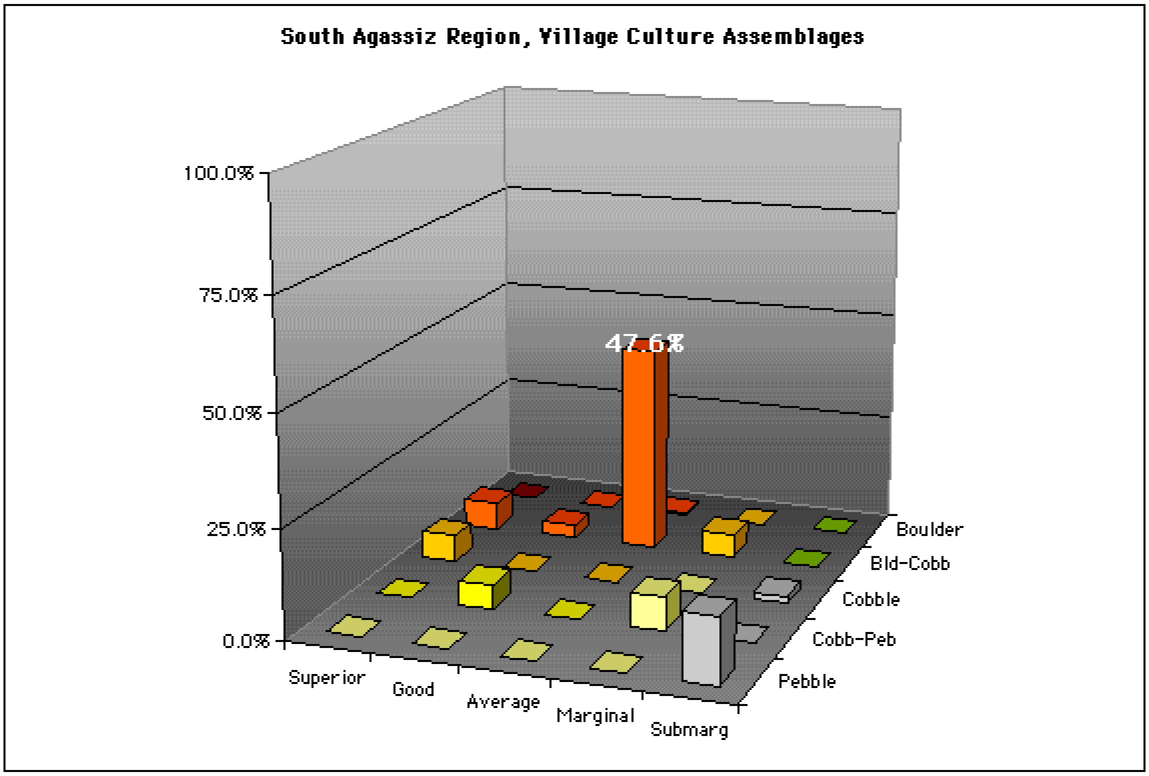
Second, we should not expect that a raw material will have the same distribution of package sizes throughout its natural area of occurrence. This is because transport, whether glacial or fluvial, tends to reduce the size of clasts (a process called comminution); longer transport equals smaller average clast size. Red River Chert again provides one kind of example. RRC seems to be especially susceptible to fragmentation during transport, and we can expect a steady falloff in size with increased distance from the primary geologic source in the Winnipeg lowlands. The average size of RRC clasts should be larger in the northern part of the Tamarack Subregion than in the southern part of the Shetek Subregion. Even in parts of the Tamarack Subregion, RRC is so reduced in size that it served principally as stock for bipolar pebble reduction (cf. Gonsior and Radford 2005), so in the southern Shetek Subregion most clasts of RRC might conceivably be fragmented beyond the point of any utility. In a case like this – with a single vector of transport – we can describe a straightforward dropoff in clast size with increased distance from the primary geologic source.

Tongue River Silica provides a different kind of example. It seems that TRS in older tills (e.g., the Pipestone Region, the apparently-corresponding old till along the eastern margin of the Des Moines lobe moraines, or glacial sediments in parts of North Dakota) contains very large pieces of TRS. Gonsior (personal communication 26 December 2002, 23 October 2008) reports finding a boulder of TRS that was on the order of a meter across in eastern Mower or western Fillmore counties. Morrow (1994:128) reports "Cobbles of Tongue River silica up to 40 cm in diameter" in the Pipestone Region of northwestern Iowa. Ahler (1977:139) reports finding boulders of TRS in the Missouri River trench, which is closer to the presumed primary source of TRS. These pieces of the material have probably undergone just one primary vector of transport from the primary geologic source. In Des Moines or Wadena lobe till, however, TRS has presumably been incorporated from older till and subjected to one or more additional vectors of transport. In such contexts, it seems that TRS rarely exceeds about 15 cm in maximum dimension. Thus we cannot characterize the size distribution of TRS clasts only by reference to distance from primary geologic source. Instead we see more of a patchwork distribution, and have to assess local use of TRS based on local conditions. This directly relates to the idea of raw material zones (Chapter 3).

Given these factors, the best way to depict the size of raw material stock in the utility plane and conceptual space would be as an S-curve. However, this creates certain technical and analytical complications. The reader is therefore asked to simply bear in mind that while each raw material is placed in the utility plane based on largest common size, the size distribution normally continues strong in the direction of decreasing size and trails off in the direction of increasing size.

Similar caveats apply to the discussion of flaking quality. First, there is simply some variation in the flakability of different pieces of any given raw materials. This was often noted in the raw material descriptions quoted in Chapter 3. In this case we probably have to focus on the prevailing quality. We should also consider the role of raw material selection by prehistoric flintknappers and how this might have changed through time. Was there, for example, an early preference for better quality PdC and an easing of selection standards through time? While this might be a productive line of questioning, it is unfortunately beyond the limits of the current research.

Figure 4-10. Utility analysis XYZ depiction of aggregated village culture assemblage data from the South Agassiz Resource Region.



Second, environmental conditions or geographic transport can lead to reduced flaking quality. In the case of the Animikie Group, for example, the best quality toolstone is associated with primary geologic sources, while researchers repeatedly noted that glacially-transported toolstone was almost all badly fractured and much less flakable. Similarly, researchers sometimes observed that toolstone from surficial sources seemed to be less flakable on account of drying or weathering, while the same material from subsurface sources was generally flakable. Here, in contrast to the case in the preceding paragraph, we may be able to account for quality variation in our analyses. In effect we could move raw materials in the utility plane to better reflect "zonal" conditions. For an assemblage near Thunder Bay, for example, we might consider Jasper Taconite to be a good (or better) quality, boulder-size raw material. For an assemblage from the Mille Lacs region, in contrast, Jasper Taconite might be better considered as an average quality, cobble- (or pebble-) size raw material.

So, for a host of reasons, the placement of individual raw materials in the utility plane is challenging. The placement presented here should be considered a first effort rather than a final, authoritative guide. That is a large part of the reason for the extensive quotation of sources in the preceding presentation of information on raw material quality, package size and abundance (Chapter 3). I hope that individual researchers will review the quoted, primary-source information and evaluate my interpretations. This, along with the addition of further research and individual expertise, should help us refine the placement of raw materials in the utility plane and thereby produce a more consistent, useful tool.

Table 4-3 lists the initial placements of regionally occurring raw materials in the utility plane, based on the information summarized in Chapter 3. These placements represent the general characteristics of each raw material from a statewide perspective, with no attempt to localize the utility plane configuration for different parts of the state or "zones." Some regionally-occurring raw materials have not yet been located in the utility plane. In some cases these materials have not been placed because sufficient information was not found on flaking quality or package size. In many cases, it was because the materials occur at such low frequency that it did not seem immediately necessary to expend the effort needed to determine their characteristics and to allow their placement. Their placements should eventually be determined. The generic raw material identification materials were not placed because they are not associated with specific raw materials, and therefore there is no association with specific flaking quality or package size.

At this point, we should be prepared to use the conceptual space. In the next section of the discussion we can begin putting it to use, first in examining some broad, general trends, and then in looking at more specific data.

LOOKING FOR TRENDS IN THE LITHIC DATA

To begin a search for broad patterns or trends in raw material use, we can look at three basic kinds of evidence – aggregated data, selected assemblages, and multicomponent sites. Each of these can be examined through the lens of the analytical construct laid out above. In addition, we can make use of clues from previous research and other researchers.

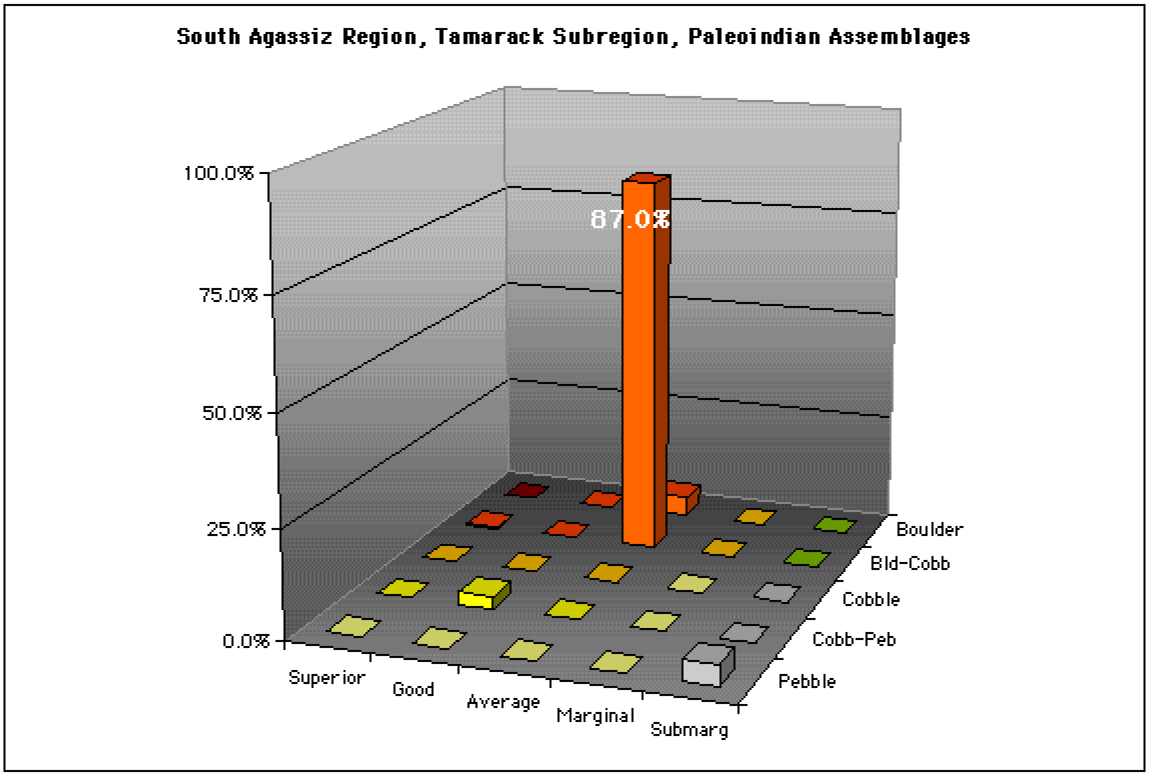
These basic sets of data are summarized in a series of tables, using a consistent format to facilitate comparison. The data are also presented in graphic form, using the XYZ conceptual space described above. The XYZ figures for aggregated assemblages are interspersed with the text, while the figures for individual sites and assemblages are provided in Appendix 2, along with basic data on each assemblage (e.g., sample size, age when known, raw material inventory). In Appendix 2 there is one page for each assemblage (or part of an assemblage, in a few cases). These are ordered by Smithsonian trinomial (e.g., 21NR29) for American sites, and then by Borden number (e.g., DcJh-4) for Canadian sites.

This evidence from aggregated data should give us our broadest perspective on significant long-terms trends in raw material use. This is a roughly chronological aggregation. It includes as many assemblages as possible, separated into very broad categories (see Chapter 2). This approximately chronological aggregation begins by separating assemblages into aceramic and ceramic, when this can be determined with some minimal degree of confidence. (Sites for which this cannot be determined are excluded from the aggregation.) The aceramic assemblages are then separated into a smaller set of assemblages that are demonstrably or apparently Paleoindian, and a larger set of all other aceramic assemblages. The ceramic assemblages are similarly separated into a smaller set of assemblages that are likely associated with village cultures (Mississippian, Oneota, Plains Village), and a larger set of all other ceramic assemblages (i.e., Woodland).

In the case of most larger assemblages, the assignment to a particular category was made by consulting the site report (when available). In the case of small assemblages, site reports were reviewed as feasible, but in many cases only the artifact catalog was reviewed for the presence of diagnostic artifacts. This was a practicality, since many of the data sets were received in the form of artifact catalogs that did not reference a particular report, and a prohibitive amount of time would have been required to track down reports for a large number of small assemblages. The aggregated figures may include several hundred assemblages; the population for each data set is noted in the respective tables.

It should be apparent, and must be clearly understood, that the separation of assemblages into these four categories is imperfect. The general aceramic category, for example, likely contains some assemblages that should be in the Paleoindian category, as well as some assemblages that originated with ceramic-using groups but by happenstance do not contain any ceramic artifacts. This should not be a fatal flaw, however, as long as 1) most assemblages were assigned to the appropriate category, and 2) any underlying patterns in raw material use are sufficiently robust. Regarding the first point, we can note that this aggregation was first done on a county-by-county basis, and the county results were then further combined by resource region or subregion. It appears that in a few counties, the incorrect assignment of assemblages may have in fact been a problem (although other factors may have contributed). However, when a larger number of assemblages are aggregated from multiple counties within a region or subregion, the problem appears to recede. Perhaps the data from the problematic counties could have been excluded altogether, but this risks

Figure 4-11. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the Tamarack Subregion, South Agassiz Resource Region.



ignoring part of the relevant evidence without specific cause. Regarding the second point, I maintain that the data indicate that underlying raw material use patterns are, in fact, sufficiently robust to be clearly detected despite some data problems. Readers will be able to judge this for themselves, however, as the data are reviewed. It should also be kept in mind that this line of evidence offers an initial look at general trends, and the results can be checked and refined by examination of additional evidence.

Among other factors, we might also consider the influence of anomalous assemblages. This was considered during aggregation of the data, and dealt with to the degree possible. Anomalous assemblages were excluded at this stage, although many are considered in the later discussion of selected assemblages. An example helps to illustrate this. Basswood Shores (Appendix 2: 21DL90; Justin and Schuster 1994) represents the short-term use of the site by a late-prehistoric group; the age of the site was assessed on the basis of a ^{14}C date and the remains of two Sandy Lake ceramic vessels. The lithic assemblage is composed almost entirely of Maynes Creek Chert, a raw material from central Iowa. Although Maynes Creek appears in small amounts at a number of other sites in the state, it is uncommon this far north and no other inventoried site (statewide) has anywhere near this amount of the raw material – either by raw count or by percentage of assemblage. Including this assemblage in the aggregations presented in the tables would exaggerate the importance of Maynes Creek both in the region where the site was found and in the general ceramic aggregation. Therefore it was excluded at this stage. Since the site provides a larger, dated lithic assemblage, however, Basswood Shores is discussed later on in the context of selected assemblages. In that context it is possible to provide a more nuanced interpretation.

A third potential concern is that the divisions used for aggregations are not relevant, or that they are biased in favor of the broad culture-historical outlines we apply to prehistory. In response I would say that I tried various approaches to aggregating the data, and found these categories to be more useful than others I tried. That is not to say that these broad categories are adequate and sufficient; plainly they are not, and they hide some important trends in the data. At this stage, however, we are taking a first broad look. Once we have the big picture in mind, we can proceed to subtler features.

Tables 4-4 through 4-13 present the underlying raw material numbers for different parts of the state. These form two series. Tables 4-7 to 4-12 are set up to facilitate comparison between different "time periods" within a single resource region or subregion, while Tables 4-4, 4-5, 4-6 and 4-13 are set up to facilitate comparison between different resource regions with a single "time period." (i.e., Paleoindian, aceramic, ceramic, village cultures). Note that lesser-used raw materials are not included in these tables, in order to focus attention on the most informative numbers. Figures 4-3 to 4-34 display the data in the XYZ conceptual space. These displays emphasize not the raw material constituents of the assemblages, but the potential utility of those raw materials.

The evidence from selected assemblages gives us another way to check any apparent trends seen in the aggregated (and multicomponent) data, but to do so with better chronological control. In addition, this evidence has the potential to let us see any developments or trends *within* the broader patterns highlighted by the aggregated data. These might include, for example, changes in patterns of raw material circulation through time, and any corresponding changes in local raw material provisioning. When possible, the assemblages included in this discussion are apparently single component and have an associated absolute date. However, since radiometric dates are not particularly abundant in the state and region, the discussion also includes assemblages that are apparently single component and have an associated relative date.

The selected assemblages include those that meet two criteria. First, the sample size should be adequate (although some exceptions are made and noted). This means that the assemblage must closely approach or exceed the rule-of-thumb threshold of 100 artifacts (Chapter 2). Second, there must be some reasonable evidence for chronological or cultural affiliations. This might include absolute dates (usually ^{14}C, less often thermoluminescence), diagnostic artifacts (e.g., typable projectile points, ceramic rims or decorated sherds, a channel flake), or stratigraphic information.

The evidence from multicomponent and potentially multicomponent sites gives us yet another way to check the apparent trends seen in the aggregated data, but to do so – at least hypothetically – with good control over raw material availability. Each of the sites providing assemblages in this category is a fixed point on the landscape, and we can hypothesize *relatively* stable local raw material access at this point. That is to say, the underlying natural resource base for raw materials should have been steady through time, whether the base was associated with glacial sediments or bedrock. There may well be questions involving such matters as resource depletion or varying erosional exposure. Such factors might affect the effort needed to gather toolstone, but they likely do not change the resource base. In addition, such factors might well play into the very changes in raw material use that we are trying to discover and understand. And as with the selected assemblages, this line of evidence has the potential to let us see any developments or trends within the broader trends highlighted by the aggregated data

The category of potentially multicomponent sites includes three basic kinds of sites. The first kind includes sites with a deep artifact-bearing sediment column, at least tens of centimeters and preferably a meter or more. The artifacts can be continuously distributed through the soil column, or there may be peaks and gaps in artifact counts. It is not necessary that independent lines of evidence confirm the presence of multiple components, although this can be the case. The second kind includes sites with different identified and vertically distinguishable components; different components occur at different depths. The third kind includes sites with different identified, horizontally distinguishable components; different components occur on different parts of the landscape. The multiple components were usually identified by the original investigators, although in a few cases the components were identified by my re-interpretation of the results presented in site reports and artifact catalogs.

The various assemblages discussed below represent a selection from the data sets that I was able to identify and procure. In making my selection I have tried to include not only assemblages that seem to me to be typical and support my interpretation of raw material use patterns, but also assemblages that do not seem to fit, or that illustrate complications that can arise in applying this sort of utility analysis. Many assemblages were excluded because they seem to present hopelessly commingled components; unfortunately, this is a particular problem in some landscapes (e.g., the vicinity of Mille Lacs Lake), which means these landscapes play little part in the discussion. Others were excluded because good contextual data could not be found. And some potentially illuminating assemblages were not included because there was a need to control the length of the discussion. In addition, there are certainly other sites and assemblages that could contribute substantially to the discussion, or even help to answer questions that come up, but which I overlooked or did not manage to identify. Hopefully the evidence that I selected will serve to make the case, and evidence that was excluded or overlooked can be considered in the future.

The following pages present a review of lithic data from the perspective of the XYZ analytical construct. Each section of the discussion (Paleoindian, Aceramic and Archaic, Ceramic and Woodland, Village Culture) begins with examination of regionally aggregated data. This is followed by examination of data from selected sites, whether single component or multicomponent. To the extent practical, the discussion begins with earlier assemblages and proceeds to more recent assemblages. Since some sites include different components, and in some cases components of unknown absolute age, it is not always possible to strictly follow chronology.

Finally, each section concludes with a review of observations on raw material use by other researchers. These are generally restricted to comments that pertain to raw material use in particular time periods, and the changes in raw material use between time periods.

Paleoindian Data

Aggregated Data

In the aggregated Paleoindian data, we see a strong tendency for selection of raw materials that fall in the UP-1 utility sector (Figures 4-3, 4-7, 4-11, 4-14, 4-18, 4-22, 4-25, 4-28 and 4-31). This usually takes the form of a single column that represents 80 percent or more of the aggregated assemblage. If we add together the percentages for all six cells in the UP-1 sector, we get the figures presented in Table 4-14 under the Paleoindian column. Note that

Table 4-6. Intensity of use for selected lithic raw materials for potential Paleoindian assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Potential Paleoindian Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
South Agassiz Materials	**22.4**	**89.3**	**-**		**-**
Red River Chert	0.8	3.0	-		-
Silicified Wood	-	-	-		-
Swan River Chert	21.6	86.4	-		-
West Superior Materials	**5.7**	**0.1**	**7.8**		**-**
Animikie Group (*not specified*)	-	-	-		-
- Biwabik Silica	-	-	-		-
- Gunflint Silica	0.9	-	1.2		-
- Jasper Taconite	4.0	-	5.5		-
- Kakabeka Chert	0.2	-	0.3		-
Fat Rock Quartz					
Hudson Bay Lowland Chert	0.5	0.1	0.7		-
Lake Superior Agate	-	-	-		-
Pipestone Materials	**-**	**-**	**-**		**-**
Hollandale Materials	**2.0**	**-**	**-**		**98.9**
Cedar Valley Chert	0.1	-	-		5.0
Galena Chert	1.8	-	-		90.8
Grand Meadow Chert	0.1	-	-		2.6
Prairie du Chien Chert	-	-	-		0.5
Shell Rock Chert	-	-	-		-
Tongue River Silica	**-**	**0.1**	**-**		**-**
Border Lakes Greenstone Group	**61.1**	**4.9**	**82.0**		**-**
Knife Lake Siltstone	59.4	0.7	81.3		-
Lake of the Woods Siltstone	-	-	-		-
Lake of the Woods Rhyolite	1.6	4.2	0.8		-
Sioux Quartzite Group	**-**	**-**	**-**		**-**
Western River Gravels Group	**-**	**-**	**-**		**-**
Quartz (*not specified*)	**2.5**	**0.1**	**3.4**		**-**
Other (*cf. chopping tool matls*)	**1.9**	**0.4**	**2.5**		**-**

Table 4-6. Intensity of use for selected lithic raw materials for potential Paleoindian assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Potential Paleoindian Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
Generic Identifications	**4.3**	**4.6**	**4.3**		**0.3**
Exotic Materials	**0.2**	**0.6**	**-**		**0.8**
Burlington Chert	-	-	-		0.3
Hixton Quartzite	-	-	-		0.5
Knife River Flint	0.1	0.6	-		-
Obsidian	**-**	**-**	**-**		**-**
Other Nonlocal Materials	-	-	-		-
Fusilinid Group	-	-	-		-
Maynes Creek Chert	-	-	-		-
Sample Size	*19,218*	*4,812*	*14,015*	*0*	*380*

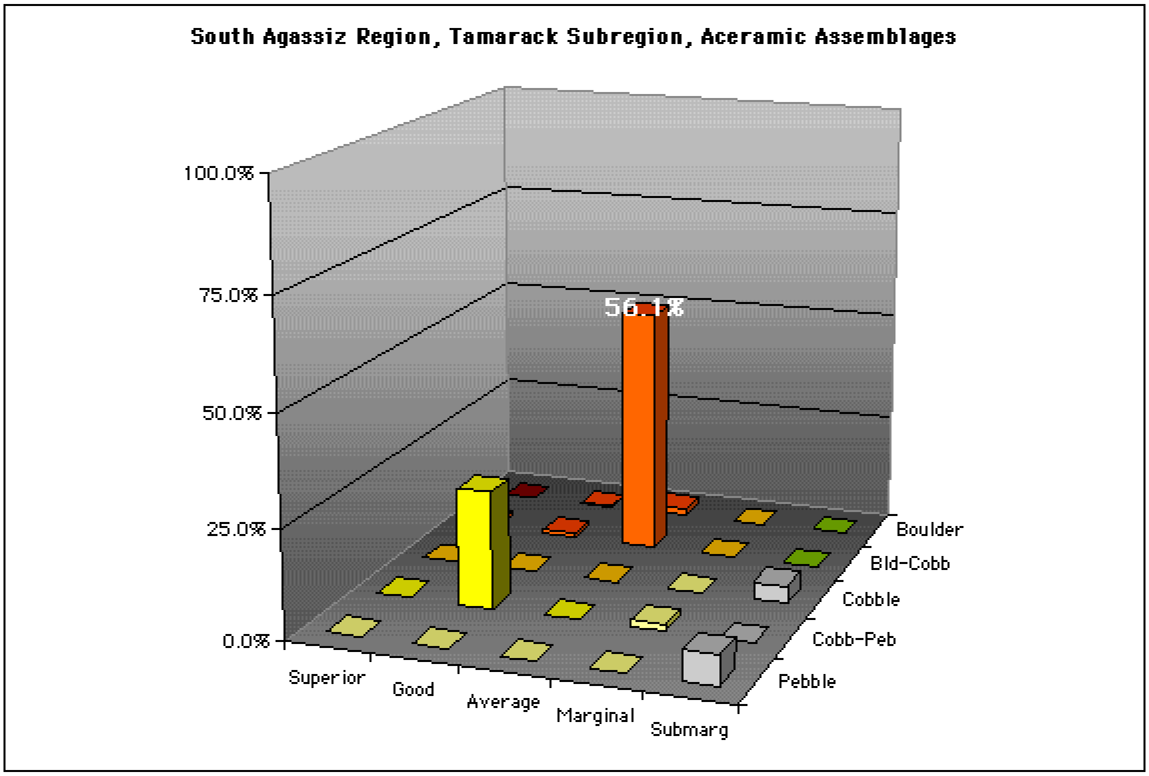
This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample. The "Minn Statewide" column includes data from counties that lie in more than one resource region; these counties are not included in the regional columns.

these figures are very high, ranging from 85.0 to 97.1 percent. Very little provisioning is distributed in the other parts of the utility plane. In other words, these flintknappers are ignoring the raw materials of smaller package size, as well as much of the poorer quality raw materials.

A look at the underlying data for the eight regions or subregions (Tables 4-6, 4-7, 4-9 to 4-12) shows a dependence on a limited set of raw materials. In the South Agassiz Resource Region, this material is usually Swan River Chert, although it can also be Lake of the Woods Rhyolite. In the West Superior Resource Region, the raw material is most commonly Knife Lake Siltstone, although Jasper Taconite dominates in proximity to its bedrock sources. In the Hollandale Resource Region, Galena Chert appears to be the dominant raw material. This dominance, however, reflects a sampling issue.

Most of the sample (n=379 of 380 pieces, 2 assemblages) comes from the Tessum/Lunde site, which is located at a Galena Chert source (Appendix 2: 21FL67; Gonsior et al. 1994). A

Figure 4-12. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the Tamarack Subregion, South Agassiz Resource Region.



look at a separate body of data suggests that other regional raw materials are at least as important in regional Paleoindian assemblages. These data come from an inventory of fluted Early Paleoindian projectile points (Table 4-15; Anfinson 2007; Bakken 2002b; Higginbottom 1996; Higginbottom and Shane 1996), and an inventory of lanceolate Late Paleoindian points (Table 4-16; Florin 1996). In the main set of Early Paleoindian data, nine points are made of Hollandale Resource Region raw materials; eight of these are Cedar Valley Chert, and one is Grand Meadow Chert. This includes a minimum of three CVC points from a recently reported Clovis site near Rochester (21OL39; Anfinson 2007:iv, 17-18; B. Koenen, personal communication 2011). In the Late Paleoindian data, 51 points are made of Hollandale materials; 5 of these are Cedar Valley Chert, 7 are Galena Chert, 1 is Grand Meadow Chert, and 38 are Prairie du Chien Chert. These data suggest that Cedar Valley and Prairie du Chien cherts are if anything more important than Galena Chert in local Paleoindian technologies.

The results for the Upper Red Subregion (Figure 4-14) require a brief discussion. In this case, the average-flaking-quality, boulder-package-size column is tallest, but it constitutes only about 50 percent of the assemblage. Several other cells contain a few percentage points of the assemblage. A look at the underlying data shows that this deviation from the pattern results mostly from the inclusion of one site, 21TR76-77. Typological diagnostics from the site indicate the presence of a Paleoindian component but not later components. The raw material profile for the site, however, does not look typical for other Paleoindian assemblages from the resource region. While this hints that a later component might be present, there is no separate evidence for this interpretation and it would be safer to interpret 21TR76-77 as an atypical Paleoindian site in terms of raw material use.

The intensity of focus on a limited suite of raw materials goes hand in hand with a strong focus on local raw materials. Exotic and other nonlocal raw materials do occur. The projectile point data cited above (Florin 1996; Higginbottom 1996; Higginbottom and Shane 1996) clearly show that materials do circulate in the raw material economy represented by these assemblages. For the Early Paleoindian (Table 4-15) points, 46.4 percent of the points are made from identifiable exotic or other nonlocal raw materials, and some of the unidentified raw materials could well be nonlocal as well. For the Late Paleoindian points (Table 4-16), the figure is 26.8 percent, with the same caveat about the unidentified raw materials. But while the projectile point data alone might give the impression that exotic and other nonlocal materials are quite common, the data from complete assemblages show that these materials normally constitute a very limited part of the total. The same is usually true of materials from adjacent regions; a site in the South Agassiz region, for example is unlikely to contain anything but traces of materials from the West Superior or Hollandale regions.

21RO11, Greenbush and 21RO-, Branvold

The Greenbush site was a lithic procurement and workshop site located on a Glacial Lake Agassiz beach ridge in Roseau County, near the northwestern corner of the state. This falls in the Tamarack Subregion of the South Agassiz Resource Region. The site was excavated in the 1970s in preparation for highway work (Peterson 1973). Although stone can be quite rare on the Agassiz lakebottom itself, my own sampling indicated that in this vicinity stone is not uncommon on the lakebottom to the north of the beach ridge, and the Swan River Chert is relatively abundant in this part of the beach ridge. Although the investigators were somewhat reluctant to conclude that this was a Late Paleoindian site, based on a first-hand examination of the assemblage I feel that that conclusion is warranted.

As noted, Swan River Chert and Lake of the Woods Rhyolite are favored materials in Late Paleoindian assemblages in this region. Both are present at Greenbush, with SRC constituting 87.0 percent of the assemblage, and Lake of the Woods Rhyolite constituting 4.7 percent. Together these total 91.7 percent (of 4,238 pieces), which is most of the total UP-1 provisioning of 91.9 percent. This matches the sort of pattern seen above for Paleoindian assemblages. This pattern includes strong reliance on local resources, generally a strong focus on a single material, and a strong preference for selection of materials that occur in the size range of boulders. This is perhaps most easily explained by the need for large cores to produce large flake blanks, that are in turn used to produce the sorts of large bifaces that are characteristic of Paleoindian technologies.

The assemblage does include a small amount of Knife River Flint (n=9, %=0.2). This indicates connections, whether by exchange or direct procurement, to distant toolstone sources. It also suggests, however, a relatively low-intensity movement of such materials. In other words, materials might come from a relatively great distance, but only in relatively small amounts. The assemblage also includes some Red River Chert (n=122, %=2.9). Because RRC is locally available in cobble to pebble size packages, it might seem out of place in this assemblage. However, the distinctive color patterning of RRC allowed a casual reconstruction of a RRC core by myself and the late Riaz Malik, and this reconstruction does shed some light on the issue. We observed that the flintknapper had selected a small RRC cobble, but one that was larger than average for that material. In addition, the cobble had a fortuitous shape that might be described as somewhat elongated and lenticular, and this shape apparently shortened the biface reduction sequence. Thus the flintknapper had been able to produce a larger than expected biface, with less loss of raw material than might have been the case for, say, a blocky or spherical rock of similar size. While the resulting biface (which was apparently not recovered) was perhaps not large by absolute standards, it was still larger than might have been anticipated – and arguably large enough to suit the flintknapper, since it had been produced and apparently transported off the site.

The Branvold assemblage comes from nearby along the same beach ridge, and also in Roseau County (Appendix 2: 21RO, Branvold; Magner, personal communication 1990). This site is also assigned a Late Paleoindian affiliation based on the presence of distinctive lanceolate projectile points. Although this is a small assemblage (n=71), it makes an instructive comparison with the Greenbush sample. At Branvold, SRC constitutes 91.5

percent of the assemblage, a figure that is remarkably close to the 91.7 percent for SRC and Lake of the Woods Rhyolite at Greenbush. KRF is also present (n=2, %=2.8), as is RRC (n=2, %=2.8). This clearly resembles the Greenbush sample, and also fits the general pattern seen above in the aggregated Paleoindian data.

21ML42, Bradbury Brook

The Bradbury Brook site is a lithic procurement and workshop site located near the confluence of Bradbury Brook and the Rum River, a few miles south of Mille Lacs Lake in east-central Minnesota. The site falls in the Quartz Subregion of the West Superior Resource Region. The site was investigated in the fall of 1989 and summer of 1990 in preparation for highway expansion. The site included multiple artifact concentrations; two were interpreted as lithic workshops, and one as an associated habitation locale. (Another small concentration related to a later use of the site, and was reported but not included in the analysis.) Boulders of Knife Lake Siltstone were gathered at the site, possibly from the bed of Bradbury Brook. Alternatively they may have been dug up at the actual workshop locations; rock piles at a field margin in the site contained abundant small boulder of KLS. The site was dated by the presence of an Alberta point base, and a radiocarbon date of 9220 ± 75 BP obtained from a charcoal sample recovered from a pit feature (Malik and Bakken 1999).

As with many other Paleoindian sites in the West Superior Resource Region, Knife Lake Siltstone was the preferred raw material at Bradbury Brook. In this case, in fact, 99.9 percent of the assemblage (126,726 of 126,852 pieces) was KLS. The abundance and density of the KLS flaking debris suggests a fairly intensive episode of raw material extraction and reduction. The condition of anvilstones and hammerstones at the site provides an additional observation on this point. Many of the hammerstones and even boulder-size anvil stone were split into pieces, suggesting the use of fairly extreme force in parts of the reduction sequence. In fact, refitting of hammerstones and anvils provided an important line of evidence in interpreting the site as representing a single episode of comparatively brief duration. Refitting of KLS flaking debris might provide valuable evidence on core form and other aspects of the reduction sequence at the site, although it may be fair to note that the research team considered the prospect too daunting to undertake given the characteristics of the raw material and volume of flaking debris.

Thus Bradbury Brook clearly conforms to the raw material use pattern seen with other Paleoindian assemblages, with raw material selection is tightly focused in the UP-1 sector of

Table 4-7. Intensity of lithic raw material use in the Hollandale Resource Region by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Hollandale Region	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
South Agassiz Materials	**4.7**	**-**	**6.0**	**8.0**	**0.6**
Red River Chert	0.7	-	0.6	1.6	0.1
Silicified Wood	-	-	-	0.1	-
Swan River Chert	3.9	-	5.4	6.3	0.5
West Superior Materials	**0.4**	**-**	**-**	**1.2**	**-**
Animikie Group (*not specified*)	-	-	-	0.1	-
- Biwabik Silica	-	-	-	-	-
- Gunflint Silica	0.1	-	-	0.2	-
- Jasper Taconite	-	-	-	0.1	-
- Kakabeka Chert	-	-	-	-	-
Fat Rock Quartz					
Hudson Bay Lowland Chert	0.2	-	-	0.5	-
Lake Superior Agate	-	-	-	0.2	-
Pipestone Materials	**-**	**-**	**-**	**-**	**-**
Hollandale Materials	**77.6**	**98.9**	**83.8**	**72.4**	**73.7**
Cedar Valley Chert	5.1	5.0	9.2	4.8	0.8
Galena Chert	14.0	90.8	5.3	26.4	5.2
Grand Meadow Chert	11.5	2.6	9.1	5.6	20.3
Prairie du Chien Chert	46.8	0.5	60.3	35.5	46.8
Shell Rock Chert	-	-	-	0.1	-
Tongue River Silica	**0.4**	**-**	**0.4**	**0.9**	**-**
Border Lakes Greenstone Group	**0.3**	**-**	**0.2**	**0.9**	**-**
Knife Lake Siltstone	0.2	-	0.2	0.5	-
Lake of the Woods Siltstone	-	-	-	-	-
Lake of the Woods Rhyolite	0.1	-	-	0.4	-
Sioux Quartzite Group	**-**	**-**	**-**	**-**	**-**
Western River Gravels Group	**-**	**-**	**-**	**-**	**-**
Quartz (*not specified*)	**1.8**	**-**	**1.6**	**4.1**	**0.1**
Other (*cf. chopping tool matls*)	**0.2**	**-**	**0.1**	**0.3**	**0.1**
Generic Identifications	**8.1**	**0.3**	**6.0**	**8.5**	**10.8**

Table 4-7. Intensity of lithic raw material use in the Hollandale Resource Region by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Hollandale Region	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
Exotic Materials	**6.4**	**0.8**	**1.6**	**3.7**	**14.7**
Burlington Chert	0.9	0.3	1.0	0.5	1.2
Hixton Quartzite	5.1	0.5	0.2	2.3	13.5
Knife River Flint	0.4	-	0.4	0.9	-
Obsidian	-	-	-	-	-
Other Nonlocal Materials	**0.1**	**-**	**0.2**	**0.1**	**-**
Fusilinid Group	-	-	-	-	-
Maynes Creek Chert	-	-	-	-	-
Sample Size	*12,857*	*380*	*4,519*	*3,819*	*4,319*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample.

the utility plane (Appendix 2: 21ML42). In this case, in fact, the percentage exceeds that which might be expected for many assemblages. We might consider that this is explained in part by the fact that this is the location of intensive raw material extraction and reduction. Consider, however, that other raw materials are present in the glacial sediments at this location, but KLS was the raw material chosen. Perhaps it would be better to consider that at sites which are not related to extraction and preliminary reduction, or perhaps represent more limited extraction and reduction, a larger proportion of the assemblage is likely to consist of artifacts relating to tool maintenance, production of flake tools from biface cores, or just simply a broader activities. In many cases, these other activities will involve tools and raw material stock that was gathered at another source and may well be other raw materials. Or it might be that the broader range of activities will permit the use of small percentages of raw materials that would not be intensively gathered (Red River Chert, for example). Either of these scenarios could explain the slightly greater diversity of some Paleoindian assemblages, and the very high – but not exorbitantly high – percentages of a primary material. In such cases, provisioning and preliminary reduction of the kind seen at Bradbury Brook would in a sense *amplify* the signal of the Paleoindian pattern, rather than obscure it.

21RN19, Thorkelson

The Thorkelson site is a multicomponent site located along Hawk Creek in Renville County, southwestern Minnesota. This falls in the Shetek Subregion of the South Agassiz Resource Region. The site was investigated several times in the 1980s in connection with planned highway work (Gonsior and Yourd 1990). The investigators identified two stratified components on a creek terrace. Neither component contained ceramics, and the lower component contained no culturally or temporally diagnostic artifacts. The investigators indicated, however, that a "limited" geomorphological reconstruction suggested that the lower component could be Late Paleoindian to Early Archaic in age.

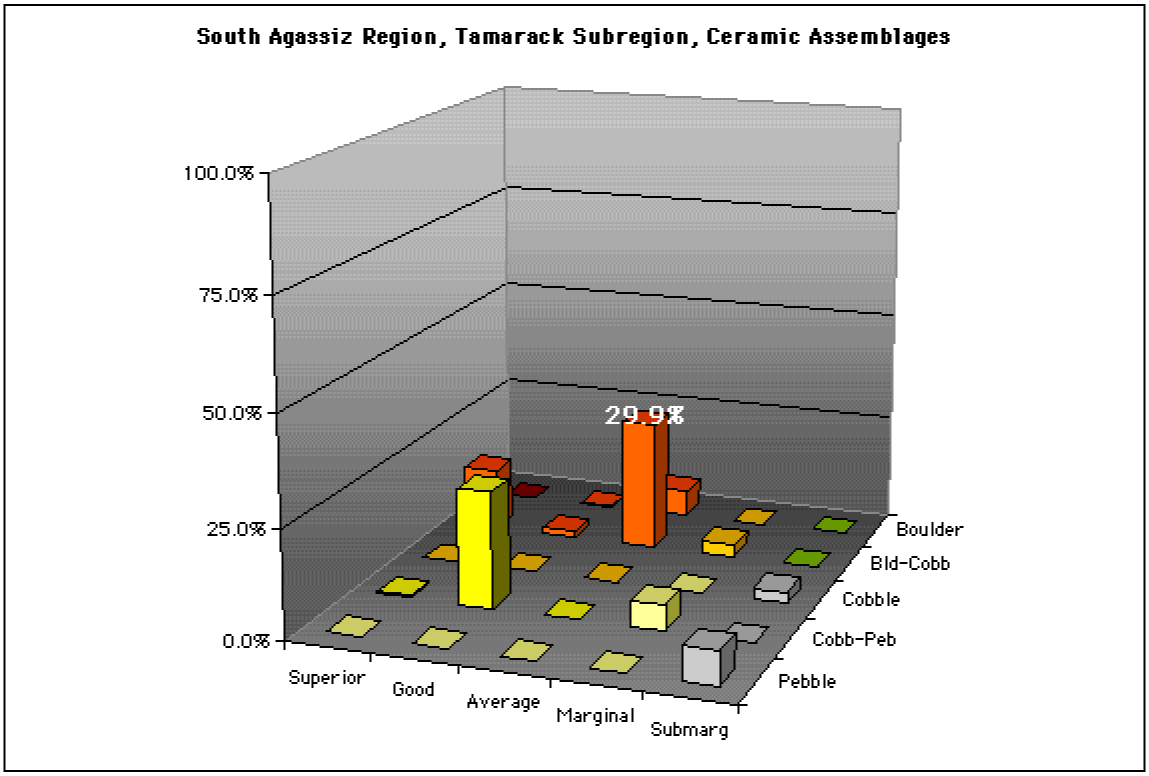
My separation of the components, based on examination of the artifact catalog and information in the report, shows a lower-component assemblage of 279 pieces. Of these, 275 (%=98.6) are Swan River Chert (Appendix 2: 21RN19). This seems to match the characteristics seen with many Paleoindian assemblages, which could be taken to confirm the early end of the suggested geomorphological age. Note that the sample did not include any Knife River Flint or other exotics, although the identification of a single piece of Cedar Valley Chert (%=0.7) would indicate a connection with a nonlocal toolstone source to the southeast. Again, this connection would seem to be of relatively low intensity.

Any interpretation should consider, however, that

> the lower component is almost exclusively derived from what appear to have been eight cores of Swan River Chert. Moreover, most of the debitage was derived from three of the cores. The debitage appears to have been thermally altered to enhance workability. The sparse amounts of cortex present in the sample suggest that several heat treated prepared cores were reduced in situ for the manufacture of stone tools within and surrounding units 1, 7, and 8. The homogeneity of the sample suggests that given a larger sample from the adjacent area, a degree of core reconstruction would be possible.... [Gonsior and Yourd 1990:21]

This is interesting for two reasons. First, because the flaking debris represents a limited number of identifiable cores, we should consider whether the excavation might have sampled an assemblage that represented a very limited window of time. In that case, the resulting sample might or might not represent the full range of raw material use. I wish to emphasize, however, that even if the sample represents a limited window of time, it still *can* be representative of the overall range of raw material use. If the suggested regional Paleoindian dependence on SRC is correct, for example, then any given sample of Paleoindian

Figure 4-13. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the Tamarack Subregion, South Agassiz Resource Region.



flintknapping – however long or short in duration the event or events – is likely to be comprised principally of Swan River Chert.

The investigators observations are also interesting for a second reason. It is not clear whether the retrieved sample would support much core reconstruction. If it did, however, or if additional excavation could enlarge the sample, then core reconstruction could potentially reveal the mode of core reduction. Such information might be to some degree diagnostic, based on comparison with similar technological information from other identified Paleoindian sites.

The upper component at Thorkelson is too small (n=22) to properly support a utility analysis. Nonetheless, it seems instructive to compare it to the lower component. We can note three main differences. First, provisioning is less concentrated in the UP-1 sector, and the provisioning that does occur in that sector is spread beyond the monolithic distribution seen in the lower component. Part of this represents the appearance of Knife River Flint, which as absent from the lower component. Second, provisioning has spread beyond the UP-

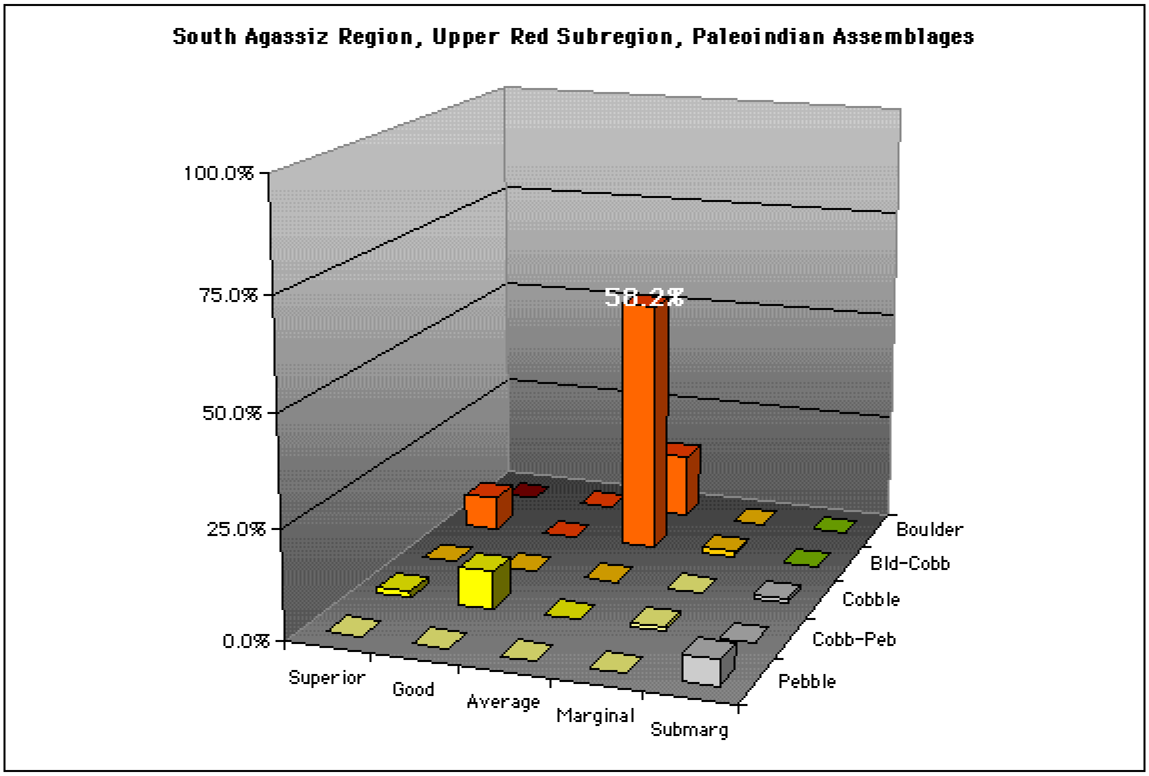
1 sector into UP-2 and UP-3. In particular this represents that presence of TRS and quartz in the assemblage. Third, the proportion of generic and unidentified materials has increased. This suggests that the upper and lower components might represent different raw material use patterns.

The investigators do note a strong resemblance between the lithic assemblages from the Thorkelson upper component and the nearby Hawk Creek site (Appendix 2: 21RN20; Gonsior and Yourd 1990). Since Hawk Creek presents a larger assemblage (n=375), we might also examine that data to get a potentially better idea of what the relevant use pattern looks like. Viewed through the lens of the XYZ construct, these two assemblages do indeed look similar. The main differences are that KRF is missing from the Hawk Creek assemblage, and that the percentage of generic and unidentified raw materials is a bit higher. This suggests that Hawk Creek and the upper component at Thorkelson might indeed represent a distinctive raw material use pattern, and that the pattern is clear in the Thorkelson upper component despite the small size of the sample. Given that both components were aceramic, and that the lower component at Thorkelson *could* (note emphasis) be Paleoindian, we might hazard a guess that Hawk Creek and the upper component at Thorkelson *could* be Archaic. This hypothesis, however, would clearly require support from other sites and assemblages.

21HB55, Beauty Lake Southwest

The Beauty Lake Southwest site provides an interesting followup on the subject of core reconstruction. Beauty Lake was a lithic procurement and workshop site located on a small terrace above Beauty Lake in Hubbard County, central Minnesota. This falls in the Quartz Subregion, West Superior Resource Region. The site was investigated in 2000 and 2001, in connection with a proposed housing development (Caine and Goltz 2002). The investigators found a granite boulder that had served as an anvilstone, surrounded by a dense scatter of Knife Lake Siltstone flaking debris. A hearth was located about 2.5 m to the southeast. The site was interpreted as representing a single event of brief duration. The investigators proposed that it was Late Paleoindian in age, based on resemblance to known Late Paleoindian assemblages and on the recovery of backing flakes that could indicate manufacture of Itasca Knives, a proposed Late Paleoindian artifact type in the Headwaters Region (Goltz 2001). A total of 1,737 lithic artifacts were recovered, of which 99.0 percent were Knife Lake Siltstone (Appendix 2: 21HB55). Other raw materials present included Swan

Figure 4-14. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the Upper Red Subregion, South Agassiz Resource Region.



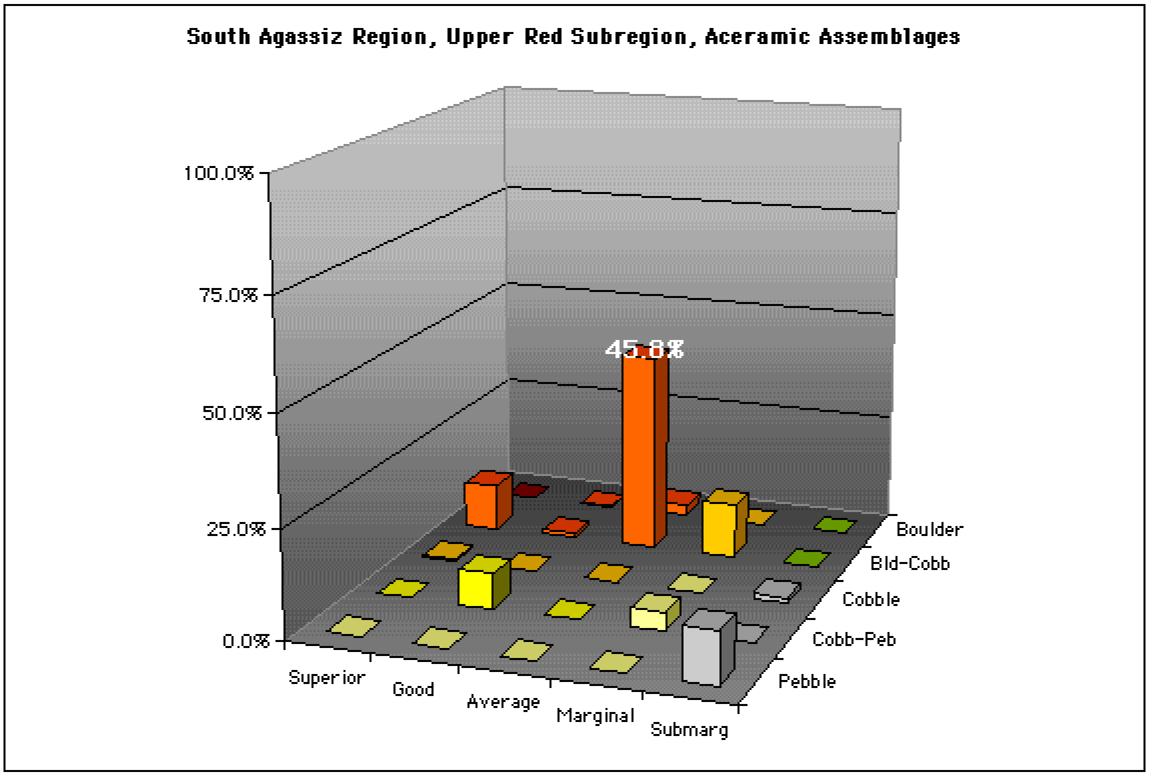
River Chert (n=4, %=0.2), Hudson Bay Lowland Chert (n=4, %=0.2), Prairie du Chien Chert (n=1, %=0.1), chert (n=4, %=0.2), quartzite (n=3, %=0.2), and quartz (n=2, %=0.1). One of the pieces of quartzite may be Hixton.

The site was small, and excavation recovered most of the contents of the site. This helped support a refitting study that managed to refit about 40 percent of the flaking debris (by weight). The refitting included a number of flake blanks, as well as early stage bifaces that were ruined and discarded during reduction. Some of these were further refitted with other flaking debris to allow substantial reconstruction of a sizeable core. Based on this reconstruction, the authors were able to describe the reduction sequence in some detail.

They describe what they believe to be the reduction of a single small KLS boulder, possibly gathered from the shoreline of the lake below the site:

> This core was likely initially 15 to 20 kilograms in mass. It was reduced as a "block core" with a single striking platform that was carefully prepared by trimming and abrading.

Figure 4-15. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the Upper Red Subregion, South Agassiz Resource Region.



> Blanks were removed consecutively around the perimeter of the core using a blade-core technology. This allowed for maximum utilization of the core material. Almost no waste material, other than flake blanks that broke during removal, was produced during this stage of the process.... The final reduction step for this core was to split the central remaining portion into two similarly sized blanks, one of which broke on impact. This portion of the reduction process required a high level of skill, planning, and preparation. Flake blanks produced average approximately 200 to 250 mm long, 80 to 100 mm wide, and 20 to 40 mm thick.... Subsequent reduction of these blanks appears to have been done at least partially by another knapper who was obviously less skilled and experienced. Several of the refit failed bifaces show a combination of poor judgement or miss-struck blows, totally inconsistent with the skill demonstrated in reduction of the core. [Caine and Goltz 2002:24]

It is interesting to discover such formal, patterned core reduction, and even more interesting to consider that it might relate to Paleoindian technology and the production of large, carefully patterned bifaces. A more casual, freehand method of core reduction seems to be far more common in regional assemblages, as does the bipolar reduction of pebble cores. If we are able to find other examples of the kind of patterned core reduction seen at Beauty Lake, and confirm its Paleoindian associations with additional evidence, this could be extremely helpful in understanding different raw material use patterns from a technological perspective.

21TR76-77

Site 21TR76-77 was initially defined as two separate sites in two different fields. However, it became apparent that the "sites" were continuous and separated only by a county road, so they are treated here as one site. The site is located on an Agassiz beach ridge in Traverse County of west-central Minnesota. This falls in the Upper Red Subregion of the South Agassiz Resource Region. The site was investigated at various times from the 1970s to the 1990s. The information considered here comes from a report by Forsberg et al. (1999). A Late Paleoindian affiliation for the site is based on the recovery of a lanceolate Browns Valley point and a flaked stone adze.

21TR76-77 provides an interesting contrast with the other Paleoindian assemblages (Appendix 2: 21TR76-77). First, while Swan River Chert is the single most common raw material in the assemblage, it constitutes only 69.4 percent (125 of 180 pieces). This is considerably lower than in other Paleoindian assemblages, which have figures nearer 90 percent (and often more). Second, KRF is present at 9.5 percent of the assemblage (n=17). This is higher than in most examples, although it should be noted that the amount of KRF in sites generally increases to the west and that sites on or near the Red River usually contain more KRF than sites even a relatively modest distance to the east.

Finally, it should be noted that 21TR76-77 contains a greater diversity of raw materials. These include Knife Lake Siltstone (n=1, %=0.6), Tongue River Silica (n=3, %=1.7), Hudson Bay Lowland Chert (n=3, %=1.7), Red River Chert (n=19, %=10.6), and quartz (n=1, %=0.6), among others. We have seen that some of these materials, Red River Chert for example, do occur in other Paleoindian assemblages, albeit in lower percentages for RRC. Other materials like HBLC and TRS are unlikely to occur regionally in Paleoindian assemblages. In any case, it seems unusual that so many atypical raw materials would occur – to the level that SRC constitutes a distinctly diminished percentage of the assemblage.

We might consider two potential explanations for this diversity and decrease in the importance of Swan River Chert. One explanation would be that this assemblage is in fact characteristic of an aspect of a Late Paleoindian raw material economy, and that not all Late

Table 4-8. Intensity of lithic raw material use in the South Agassiz Resource Region, Shetek Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

South Agassiz: Shetek Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
South Agassiz Materials	**52.7**	**98.6**	**59.1**	**44.2**	**46.8**
Red River Chert	6.2	-	7.1	6.1	5.6
Silicified Wood	0.2	-	0.4	-	-
Swan River Chert	46.3	98.6	51.6	38.1	41.3
West Superior Materials	**1.5**	**0.4**	**1.8**	**1.4**	**-**
Animikie Group (*not specified*)	-	-	-	-	-
- Biwabik Silica	-	-	-	-	-
- Gunflint Silica	0.6	0.4	1.4	0.1	-
- Jasper Taconite	0.3	-	0.2	0.4	-
- Kakabeka Chert	-	-	-	-	-
Fat Rock Quartz					
Hudson Bay Lowland Chert	-	-	0.1	-	-
Lake Superior Agate	0.5	-	0.1	0.9	-
Pipestone Materials	**0.2**	**-**	**-**	**0.2**	**2.4**
Hollandale Materials	**7.6**	**0.4**	**6.7**	**8.7**	**12.7**
Cedar Valley Chert	0.3	0.4	0.6	0.1	-
Galena Chert	0.3	-	0.2	0.5	-
Grand Meadow Chert	1.9	-	1.8	1.9	6.3
Prairie du Chien Chert	5.1	-	4.0	6.2	6.3
Shell Rock Chert	-	-	-	-	-
Tongue River Silica	**8.0**	**-**	**8.9**	**8.3**	**5.6**
Border Lakes Greenstone Group	**1.5**	**-**	**1.2**	**1.8**	**0.8**
Knife Lake Siltstone	0.5	-	0.4	0.7	-
Lake of the Woods Siltstone	-	-	-	-	-
Lake of the Woods Rhyolite	1.0	-	0.8	1.1	0.8
Sioux Quartzite Group	**0.1**	**-**	**0.1**	**-**	**-**
Western River Gravels Group	**0.3**	**-**	**-**	**0.4**	**-**
Quartz (*not specified*)	**10.5**	**0.4**	**3.4**	**16.6**	**7.9**
Other (*cf. chopping tool matls*)	**0.7**	**-**	**0.5**	**0.9**	**1.6**

Table 4-8. Intensity of lithic raw material use in the South Agassiz Resource Region, Shetek Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

South Agassiz: Shetek Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
Generic Identifications	**13.3**	**0.4**	**15.0**	**13.2**	**12.7**
Exotic Materials	**3.7**	**-**	**3.0**	**4.3**	**6.3**
Burlington Chert	0.7	-	0.6	0.8	-
Hixton Quartzite	0.1	-	0.1	0.1	-
Knife River Flint	2.7	-	2.3	3.1	6.3
Obsidian	0.22	-	-	0.41	-
Other Nonlocal Materials	**0.3**	**-**	**0.2**	**0.3**	**3.2**
Fusilinid Group	-	-	-	-	-
Maynes Creek Chert	-	-	-	-	-
Sample Size	*5,859*	*279*	*2,281*	*3,187*	*126*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample.

Paleoindian assemblages will be "typical." This explanation decreases any potential diagnostic utility of this sort of proposed raw material analysis. A second explanation is that the assemblage includes materials representing a later component and a different sort of raw material economy. In fact this is the interpretation that my analysis would suggest, which would lead me to a re-examination of the site or assemblage to see if there is any evidence for such a later component. Examples might include an unrecognized fragment of a notched point, or possibly the presence of bipolar cores. The available evidence, however, offers no support for this second interpretation, so for now at least 21TR76-77 is best viewed as a "atypical" Paleoindian assemblage.

47DN234

47DN234 is located in west-central Wisconsin. The sample from the site included the base of a broken fluted point, which Wendt (2003) compared to the Gainey type. This indicates the presence of an Early Paleoindian component. The site is located on the northern margin of the "driftless" area, suggesting that we can at least provisionally place it in the Hollandale Resource Region. Note that the presence of a corner-notched point also indicates the presence of a later component at the site.

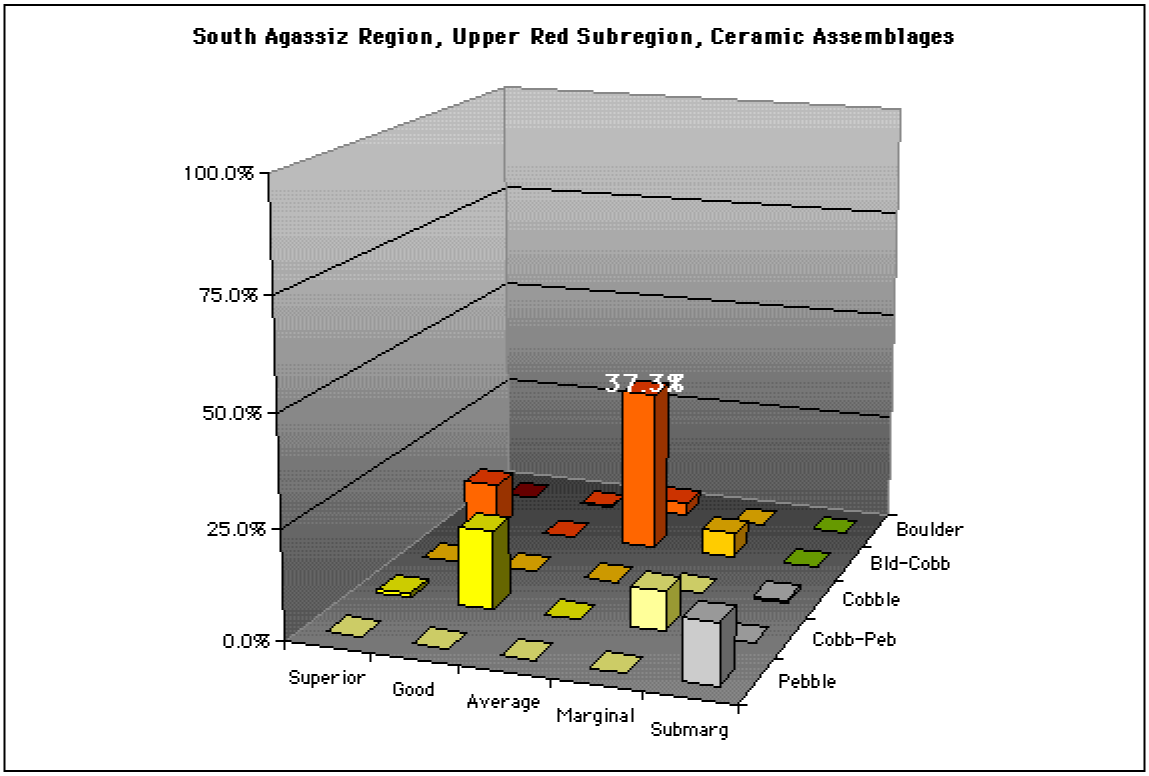
Given that this is at least to some degree at multicomponent site, it is interesting to review the character of the assemblage (n=228). The fluted point itself is made of Jasper Taconite, a raw material that outcrops near Thunder Bay and which is spread widely in the tills of the West Superior Resource Region. This is the only piece of Jasper Taconite in the assemblage. The most common raw material is local Prairie du Chien Chert (n=192, %=84.2). This and other UP-1 materials constitute 99.1 percent of the assemblage (Appendix 2: 47DN234). The other UP-1 materials include Cochrane Chert (n=30, %=13.2), and a quartzite of the Hixton Group (n=3, %=1.3).

This raw material profile is clearly comparable with other Paleoindian profiles; the XYZ depiction shows the assemblage clustering strongly in the UP-1 area of the utility plane. Yet the corner-notched point (of unidentified chert) provides clear evidence of a later component, one that we might expect would be reflected in a broader range and greater diversity of raw materials. The fact that it is not raises some interesting questions. It could be that the later component is very minor, even restricted to the corner-notched point itself. It could also be, however, that later raw material use resembles early raw material use in this region; this possibility should not be discounted, since this thesis concentrates on landscapes to the west and has little comparative information for the more immediate vicinity of 47DN234. It seems that the potential resolution of this matter requires examination of such local evidence, a matter beyond the scope of the present research. In the meantime, however, 47DN234 does provide a cautionary reminder.

The Reservoir Lakes Complex Sites (21SL-)

The Reservoir Lakes Complex data come from almost forty sites collected by Redepenning and reported by Harrison et al. (1995). The sites range from findspots yielding a single artifact to substantial artifact scatters, and representing a variety of site types and functions. At most of the sites, there is a predominant Paleoindian component (sites without a Paleoindian component are not included in the data reviewed here); a few sites have evidence for a minor Archaic component, and one for both Archaic and Woodland components. The identification of the Paleoindian components was mostly based on the presence of distinctive

Figure 4-16. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the Upper Red Subregion, South Agassiz Resource Region.



lanceolate points, sometimes on related technology, and also on resemblance to assemblages from neighboring Paleoindian complexes. The following discussion looks at aggregated data for the collection.

Knife Lake Siltstone is the most abundant material in these assemblages (n=12,020 of 14,835; %= 81.0). The researchers note that the quality varies considerably, from slate-like to cherty. The material was locally available, potentially from bedrock and definitely from glacial sediments. Other materials represented include various members of the Animikie Group, HBLC, rhyolite and quartz, as well as some generically identified or marginal quality materials. A few pieces of Hixton Quartzite were also recovered.

The aggregated Reservoir Lakes data show 88.5 percent of the raw materials fall within the UP-1 sector; most of this is KLS (Appendix 2: 21SL, Reservoir Lakes Complex). This is somewhat lower than we saw in other Paleoindian assemblages, where the figure tends to be above 90 percent. A look at the 17 constituent assemblages having more than 100 pieces shows that the figure ranges from 71.8 to 100.0 percent. There does not appear to be any particular association between suspected later components and lower percentage figures for the UP-1 total. Nor does there appear to be any association between elevated percentages of quartz and suspected later components, although we might expect such an association based on evidence from sites in other regions. Indeed, given higher percentages of raw materials outside the UP-1 sector (including generic or unidentified materials), the assemblages from ER-08, 10, 13, 30 and 35 give the appearance of containing later components. Again, this does not show any clear association with the researchers evaluations of which sites appear to contain later (principally Archaic) components.

The reasons for this are not clear. It might be that the generic raw material categories (e.g., jasper, chalcedony) are concealing important information, and that if these materials were more specifically identified and then placed in the appropriate locations in the utility plane, the results would look more like expected for Paleoindian assemblages. That would still not solve the problem of high percentages of quartz, however. It might also be that there are unrecognized later components on some of the sites, but without some sort of corroborating archaeological evidence such an explanation is little more than baseless speculation.

Despite the somewhat lower percentage of materials in the UP-1 sector, however, and in spite of a few potentially anomalous assemblages, these sites by and large show a clear affinity to the pattern seen with Paleoindian assemblages in other regions. We are probably safe in seeing these assemblages as representative of Paleoindian profiles in the Arrowhead Resource Region, and indicative of the kind of variation we might expect to see. Note that even in the cases where provisioning is occurring in sectors of the utility plane outside of UP-1, the majority of the provisioning is still occurring *within* UP-1, and the pattern looks distinctive from that seen in later assemblages. Perhaps we can seek to better clarify the issue of the more diverse assemblages as we analyze more regional assemblages in the future.

13CK405, Cherokee

The Cherokee site provides a useful look at the transition from Paleoindian to Archaic. The site is located in Cherokee County, northwestern Iowa. This likely falls in the Pipestone Resource Region. Excavations here retrieved lithic assemblages from three dated components, including Late Paleoindian (ca. 8400 BP; n=2,799), Early Archaic (ca. 7200 BP; n=10,144), and Middle Archaic (ca. 6350 BP; n=404). The published report (Anderson 1980) presents a detailed lithic inventory. Unfortunately, however, the inventory was prepared before many of the presently-recognized raw materials were identified and defined, and it instead uses a variety of descriptive categories that cannot be correlated with current raw material types. Nonetheless, we can still glean some extremely useful information from this site. Specifically, we can look at the numbers for Fusilinid Group cherts, which come from the south to southwest and are not locally available in the vicinity of the site, and Tongue River Silica, which would be a local resource. While the quality of the Fusilinid Group materials varies somewhat, they might generally be characterized as good (see Morrow 1984a, 1994), whereas TRS is clearly marginal and reputedly requires early-stage heat treatment to be considered even workable.

TRS constitutes 19.5 percent of the Late Paleoindian assemblage, 89.7 percent of the Early Archaic assemblage, and 0.7 percent of the Middle Archaic assemblage. Fusilinid Group cherts constitute 5.0 percent, 0.2 percent, and 48.8 percent, respectively. These numbers suggest dramatic changes in raw material procurement and use, especially as they pertain to the balance between local and nonlocal toolstones.

The presence of 19.5 percent TRS in the Late Paleoindian assemblage is initially surprising, given the character of other Paleoindian assemblages in the current data set. In other Late Paleoindian assemblages, there seems to be a complete avoidance of TRS. We might first ask what could account for this difference. A clue comes from an observation by Gonsior (personal communication, 26 December 2002, 23 October 2008) who found large boulders of TRS in the old tills exposed past the eastern margins of Des Moines lobe tills in southeastern Minnesota. We can postulate that these tills are related to the old tills exposed in the Pipestone Resource Region, where archaeological evidence indicates that TRS was an important resource and apparently abundant. The archaeological evidence assembled for Rock and Pipestone counties (n=303), for example, includes 22.0 percent TRS. The next highest percentage of TRS is 12.3 percent for the Quartz Subregion. This prevalence of TRS is also apparent on the map of statewide archaeological TRS distribution by county (Appendix 1-21). Gonsior's observation in turn suggests that in the Pipestone Region, TRS is available in large pieces. (This contrasts with, for example, TRS in the South Agassiz, where it appears that an additional vector of glacial transport has reduced the clast size and TRS is seldom or never found in such large pieces.) Thus despite its relatively poor flaking quality, TRS would be a potentially useable raw material in a lithic technology that selects large pieces of toolstone for the production of large bifaces. The presence of 5.0 percent of Fusilinid Group cherts is less surprising, and on a par with the levels of nonlocal raw materials in some other Late Paleoindian assemblages. Such materials and percentages suggest the presence of

Table 4-9. Intensity of lithic raw material use in the South Agassiz Resource Region, Tamarack Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

South Agassiz: Tamarack Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
South Agassiz Materials	**81.6**	**89.9**	**82.9**	**56.9**	
Red River Chert	20.4	2.9	26.8	26.8	
Silicified Wood	0.1	-	0.1	0.3	
Swan River Chert	61.0	87.0	56.0	29.8	
West Superior Materials	**6.9**	**-**	**1.0**	**2.3**	
Animikie Group (*not specified*)	-	-	-	0.2	
- Biwabik Silica	-	-	-	-	
- Gunflint Silica	0.7	-	0.8	1.5	
- Jasper Taconite	-	-	0.1	0.1	
- Kakabeka Chert	-	-	-	-	
Fat Rock Quartz					
Hudson Bay Lowland Chert	0.2	-	0.2	0.5	
Lake Superior Agate	-	-	-	-	
Pipestone Materials	**-**	**-**	**-**	**-**	
Hollandale Materials	**0.1**	**-**	**0.1**	**0.1**	
Cedar Valley Chert	-	-	-	-	
Galena Chert	-	-	-	-	
Grand Meadow Chert	-	-	-	-	
Prairie du Chien Chert	0.1	-	0.1	0.1	
Shell Rock Chert	-	-	-	-	
Tongue River Silica	**0.5**	**-**	**0.2**	**3.2**	
Border Lakes Greenstone Group	**3.0**	**4.7**	**1.6**	**6.5**	
Knife Lake Siltstone	0.4	-	0.2	2.2	
Lake of the Woods Siltstone	0.1	-	-	0.4	
Lake of the Woods Rhyolite	2.5	4.6	1.3	3.8	
Sioux Quartzite Group	**-**	**-**	**-**	**-**	
Western River Gravels Group	**-**	**-**	**-**	**-**	
Quartz (*not specified*)	**1.7**	**-**	**1.6**	**6.0**	
Other (*cf. chopping tool matls*)	**2.9**	**0.4**	**4.0**	**2.6**	

Table 4-9. Intensity of lithic raw material use in the South Agassiz Resource Region, Tamarack Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

South Agassiz: Tamarack Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
Generic Identifications	**6.4**	**4.8**	**6.9**	**7.8**	
Exotic Materials	**2.8**	**0.3**	**1.4**	**14.6**	
Burlington Chert	-	-	-	-	
Hixton Quartzite	-	-	-	-	
Knife River Flint	2.7	0.3	1.4	14.6	
Obsidian	-	-	-	-	
Other Nonlocal Materials	0.1	-	0.2	-	
Fusilinid Group	-	-	-	-	
Maynes Creek Chert	-	-	-	-	
Sample Size	*16,184*	*4,313*	*9,852*	*2,019*	*0*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample.

mid- to long-distance connections, but the movement of relatively small amounts of raw materials via these connections.

In the Early Archaic assemblage, the change to 89.7 percent TRS and 0.5 percent Fusilinid Group cherts suggests a significant change in raw material provisioning strategies. In particular it suggests an intensely local focus on provisioning, and perhaps a drastic weakening – one might postulate near collapse – of raw material circulation much beyond their source areas. Although this interpretation cannot be supported solely on the basis of the Cherokee site evidence, it makes an interesting postulate to consider in the light of evidence from other sites. In this scenario, locally-abundant TRS satisfies most needs of a reconfigured lithic economy.

In the Middle Archaic assemblage, we see another dramatic change to 0.7 percent TRS and 48.8 percent Fusilinid Group cherts. Following the same line of interpretation, this could suggest the rebuilding of lithic exchange networks or mid- to long-distance procurement, and an associated decline in the use of a locally abundant but marginal quality raw material like TRS. Again, at this point such an interpretation is not well supported, but is an interesting postulate to carry with us to the examination of other assemblages.

An re-examination of the Cherokee assemblages, and a new lithic inventory based on modern raw material categorizations, would no doubt shed some interesting light on this line of interpretation. It might also prove a profitable starting point for better understanding both the raw material resource base and raw material economies of northwestern Iowa and the Pipestone Resource Region.

Observations by Other Researchers

In addition to reviewing the data, we might gain useful insights be reviewing a few observations made by other researchers on patterns or changes in raw material use. For the Arrowhead Subregion, Mulholland and Shafer (2000:52-53) offer a particularly useful comment:

> The key to the use of Knife Lake Siltstone as a temporal indicator is not just presence. It must be examined in the context of its frequency of occurrence in the total lithic assemblage and the location of the site in a regional perspective (Mulholland, in preparation). One of the primary core areas of Knife Lake Siltstone usage occurs in central northeastern Minnesota. In this core area Knife Lake Siltstone debitage frequencies that exceed 90 percent of the debitage assemblage are indicative of Paleoindian sites. Over time the frequency of Knife Lake Siltstone as part of the debitage assemblage decreases.

This agrees nicely with the data reviewed above.

Hamilton (1996:73) offers similar observations for the use of Jasper Taconite (and other Animikie Group materials) for the part of the Arrowhead Subregion that lies in Ontario. In discussing the results of a survey near Thunder Bay, he notes that over 97 percent of the lithic artifacts were Animikie Group materials, that most were Jasper Taconite, and that KLS (%=6) is the next most common material. He goes on to state that

> The heavy reliance upon taconite is not surprising given its local availability in bedrock exposures. Since many of the sites are Plano (or probably Plano), the dominance of taconite is consistent with the already reported Plano preference for this raw material. The strength of this preference cannot be overstated. Indeed, of the literally hundreds of thousands of lithic specimens recovered from such major Plano sites as Cummins, Biloski, Brohm and DcJh-16, the vast majority is derived from the Gunflint Formation (Bill Ross 1995: pers. comm.). Halverson (1992:62) confirms this observation with her intersite comparison of raw material selection from eight Plano sites near Thunder Bay. Between 90% and 100% of the recoveries she examined are taconite or other Gunflint Formation raw materials.

For reference, Halverson's (1992:62) Table 6 and Hamilton's (1996:74) Table 4 are adapted in Tables 4-17 and 4-18. Note in both tables the very high (90-plus percent) levels for Jasper Taconite in most cases, and the very low levels for materials like quartz. And in Table 4-17, note the clear changes in raw material composition for the later Archaic and Woodland sites. These figures match nicely with the data reviewed above, with the concentration of provisioning in the UP-1 sector for the Paleoindian assemblages, and the broader disposition of provisioning beyond UP-1 for the later assemblages. It is also worth considering that the very high levels of Jasper Taconite seen in many of these assemblages compare with the numbers (for other materials) seen at a site like Bradbury Brook, and that there may be related causes at work. There are outcrops of Jasper Taconite in the vicinity of Thunder Bay. And as at Bradbury Brook, other raw materials were available. Hamilton (1996:73) goes on to note that:

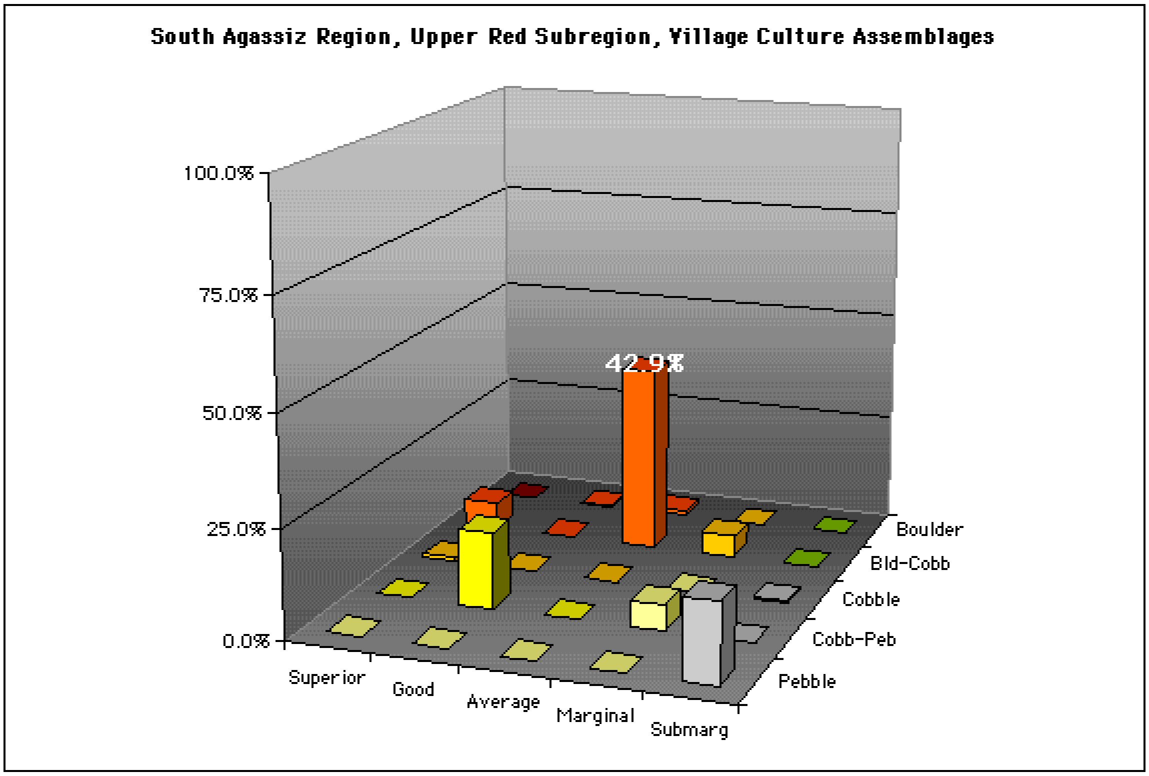
> the heavy use of taconite is remarkable given its propensity to shatter along hidden fault planes. The preference for this challenging raw material is particularly noteworthy given the local availability of cherts, quartzite and other flakeable materials in the tills and gravels upon what was then a freshly deglaciated landscape. Clearly, Plano knappers were strongly attracted to bedrock materials, and virtually ignored till-derived siliceous cobbles and pebbles. Indeed, Bill Ross (1994: pers. comm.) and others have observed a tendency for Plano people to focus upon bedrock materials such as taconite and Knife Lake siltstone, while later groups (late Archaic and Woodland) made more frequent use of fine cherts, quartz and quartzite derived from tills and stream sorted gravel deposits.

It is interesting that Hamilton (and others he cites) emphasize the distinction between bedrock and secondary, glacial sources. Given such a distinction, a useful contribution of the present research may be to change the emphasis from type of source to intrinsic characteristics of the raw materials – especially flaking quality and, perhaps most important in this context, package size.

Also for Ontario, Hinshelwood (1994) notes that use of Kakabeka Chert is low in Paleoindian assemblages, then increases with the Archaic. The use of Hudson Bay Lowland Chert also increases with the Archaic. We might hypothesize that the former is because Kakabeka Chert rarely occurs in large, useable package size, while this is almost certainly the case with HBLC.

Mulholland (2002:5) notes that Hixton "in northeastern Minnesota is most often attributable to Paleoindian contexts. It becomes increasingly less used through time, to an almost complete absence by the Woodland periods." Mulholland and Shafer (2000:52) more

Figure 4-17. Utility analysis XYZ depiction of aggregated village culture assemblage data from the Upper Red Subregion, South Agassiz Resource Region.



specifically note that "Hixton Silicified Sandstone was only occasionally utilized during the Woodland period. It was far more commonly used during the Archaic and Paleoindian periods.... Most, if not all, Hixton diagnostic artifacts and associated debitage recovered from northeastern Minnesota have been Paleoindian to Late Archaic in age." Kuehn (1998) likewise notes the presence of Hixton in Paleoindian and Archaic assemblages, and its sporadic presence in Woodland contexts. Although this does not address local raw material use, it is informative from the perspective of raw material circulation and the idea that we might be able to reconstruct histories of circulation for particular raw materials.

Morrow (1994) makes a number of interesting observations about preferential use of different raw materials in Iowa during different time periods. Most of these observations, however, cannot be related to specific resource regions and in addition are not quantified. For these reasons his observations are not immediately useful in the context of this review. He does make one particularly useful observation, however, in terms of helping to reconstruct a history of the circulation of Burlington Chert. Such a history could be quite helpful in terms of refining an understanding of raw material use in Minnesota and other parts of the region beyond Iowa. Morrow (1994:123) states that

> White Burlington chert was a preferred raw material for many Paleoindian and Early Archaic point and knife types. This material is also widespread in the form of Middle Woodland artifacts. During the latter period, more colorful varieties (yellow-tan to brilliant pink) may have been imported from northeast Missouri and west-central Illinois. White Burlington chert was also widely circulated among Oneota groups during the Late Prehistoric period.

Note that he frames Paleoindian and Early Archaic use in terms of points and knives. While this is a useful piece of information, bear in mind the discussion above of the Early and Late Paleoindian point inventories for Minnesota, and the fact that projectile point (or other tool) data is not directly comparable to data from full assemblages and can over-emphasize the importance of nonlocal raw materials. Given that caveat, Morrow's observations here might be especially interesting when compared to the circulation of Knife River Flint, and they should also be borne in mind in connection with the following discussions of Archaic or aceramic and village culture data.

Summary

In summary, we see a remarkably consistent pattern in the Paleoindian data: provisioning is concentrated in the UP-1 sector of the utility plane, usually in the form of a single raw material occurring at a level of around 90 percent of the assemblage. The identify of this raw materials varies from region to region: Swan River Chert or less often Lake of the Woods Rhyolite for the South Agassiz Resource; Knife Lake Siltstone or locally Jasper Taconite for the West Superior Resource Region; and Galena Chert, Cedar Valley Chert, and Prairie du Chien Chert in the Hollandale Resource Region. On the whole, these assemblages make little use of materials of marginal or submarginal quality, or materials that normally occur in package sizes of cobble or pebble size. Exotic and other nonlocal raw materials occur, but only in relatively small amounts. Some unidentified or generically identified raw materials may also be present, but again these are likely to occur in small amounts. Overall raw material diversity is low. Provisioning is strongly local, and at the same time quite selective: many potential toolstones are ignored, and a very narrow range are selected.

Of the various assemblages and data sets we reviewed, most match this pattern quite well.

A few show somewhat broader diversity, with the inclusion of a few more percent of raw materials outside of the UP-1 sector or perhaps somewhat increased levels of unidentified and generically identified raw materials. In most cases, however, even these somewhat atypical assemblages still bear a recognizable resemblance to the overall Paleoindian pattern. And in one case, we saw the opposite: an assemblage that apparently includes a later component based on projectile point evidence, but presents the typical Paleoindian raw material pattern.

Evidence from one site suggests that this pattern of raw material procurement and use might be associated with the reduction of formal block cores, and the production of large flake blanks. We might infer that the large flake blanks support the production of large preforms and the various kinds of large, lanceolate projectile points also associated with these assemblages.

With these characteristics of Paleoindian provisioning and raw material use in mind, we can proceed to examine date from more recent assemblages, and investigate to what degree the latter resemble or fail to resemble the Paleoindian assemblages. The next set of data includes other aceramic assemblages that do not appear to be Paleoindian, and of assemblages that are demonstrably Archaic in age.

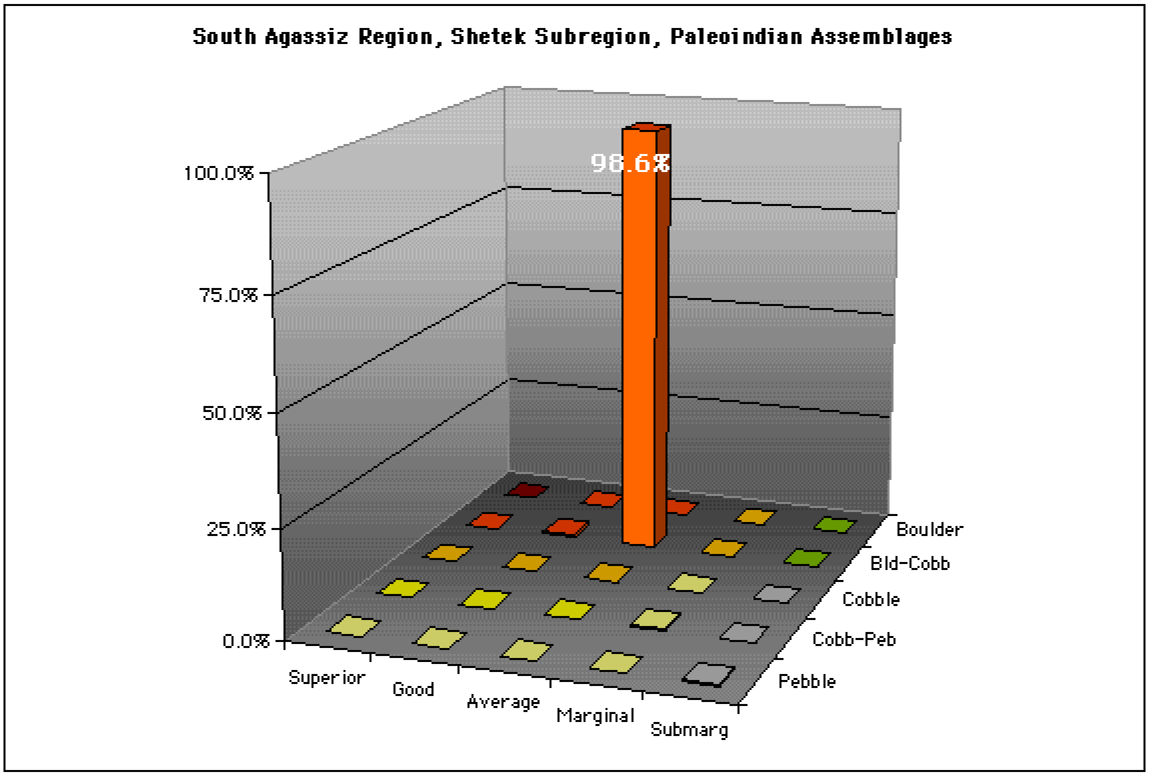
Aceramic and Archaic Data

Aggregated Data

The aggregated data shows that in the aceramic assemblages, the situation changes rather plainly. Less of the provisioning is concentrated in the sector of the utility plane that dominate in the Paleoindian assemblages (Table 4-14). Provisioning covers a broader part of the utility plane, and so includes smaller pieces and pieces of somewhat poorer flaking quality (Figures 4-4, 4-8, 4-12, 4-15, 4-19, 4-23, 4-26, 4-29, 4-32). Note that "smaller" here generally refers to cobbles, not pebbles. The data reviewed below suggest that much of the expansion occurs in the UP-2 utility sector (Table 4-20).

A look at the underlying data (Tables 4-5, 4-7 to 4-12) indicates that a few specific raw materials account for much of this change. In the South Agassiz Region generally, Red River Chert becomes more important. In the Upper Red and Shetek subregions, Tongue River Silica – previously ignored – also comes into use. In the West Superior Region Knife Lake Siltstone, by far the most important raw material in the Paleoindian assemblages, is a relatively minor material in the aceramic sample. Quartz becomes much more important,

Figure 4-18. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the Shetek Subregion, South Agassiz Resource Region.



especially in the Quartz Subregion. Tongue River Silica becomes a relatively important material in parts of the subregion. In the Hollandale Region, it appears that Prairie du Chien Chert becomes the most important raw material, although this could be in part a sampling issue. Data from the Cherokee site in Iowa (13CK405; Anderson 1980) provide a clue as to what happens in the Pipestone Region. Whereas TRS constituted 19.5 percent of the lithic assemblage from a Paleoindian horizon at the site, it rises to 89.7 percent of an aceramic, Early Archaic assemblage.

The aceramic data introduces a problem that is largely absent from the Paleoindian data, and that is the use of quartz – especially in the West Superior Resource Region and Quartz Subregion. The inventories that were used for this study list quartz as a single raw material, reflecting the state of knowledge at the time. It has recently become clear, however, that quartz from restricted sources near Little Falls (in the Quartz Subregion) is a distinct material with different – and better – flaking properties than the other quartz which occurs widely throughout the study area (Wendt, personal communication 25 Aug 2007). The Little Falls material should be identified as Fat Rock Quartz, and tallied separately in lithic inventories. It seems very likely that the Little Falls material was used differently and has a different use history than other quartz. Given the package size and general flaking quality of Fat Rock Quartz, and therefore its placement in the utility plane, we could expect that the use of Fat Rock would increase in the aceramic assemblages. Data from other parts of the state, on the other hand, suggests that the use of other quartz increases in the ceramic assemblages.

Because kinds of quartz are not distinguished in the existing data, it is effectively impossible to investigate the history of their use at present. In addition, this complicates analysis of aceramic and ceramic assemblages in or near the Quartz Subregion. For example, compare Figure 4-29 with Figure 4-8. In Figure 4-29 (aceramic assemblages, Quartz Subregion), the tall column at marginal quality, cobble-pebble package size reflects the presence of a large amount of quartz in the aggregated assemblage. In contrast, Figure 4-8 (aceramic assemblages, South Agassiz Region) shows only a minor presence of quartz or other materials at this location in the utility plane. Figure 4-29 most likely shows an inaccurate view of raw material use in the Quartz Subregion; some part of the marginal quality, cobble-pebble package size column – perhaps most of it – should occupy the cell at average quality, cobble package size. This would bring the analysis better into line with results seen in other regions. The same problem seems to pertain to the Arrowhead Subregion (see Figure 4-26). As noted, however, this matter cannot be resolved based on the available data. This points to an important concern for future research, namely the need to begin distinguishing Fat Rock from other quartz in raw material inventories. A recently-initiated reanalysis of lithics from 21ML11, the Petaga Point site, seeks to separate Fat Rock from other quartz, and in so doing begin to untangle this issue.

The aggregated aceramic data would seem to indicate first a greater role for exotic and other nonlocal raw materials than was the case in the Paleoindian data, and second some variability in the importance of these materials. A closer look at the data, however, indicates that the situation is not only more complex than that but also considerably more interesting. The Cherokee site data discussed above (Paleoindian Data) already provides some clues as to what kind of variation we might see within such a broader use pattern. In particular, the Cherokee data suggests that the importance of exotic or other extralocal raw materials might change through time, and that such changes would also influence local provisioning. The matter is better reviewed in the context of the multicomponent and selected assemblage data reviewed below.

Table 4-10. Intensity of lithic raw material use in the South Agassiz Resource Region, Upper Red Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

South Agassiz: Upper Red Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
South Agassiz Materials	**55.0**	**66.8**	**54.4**	**54.8**	**60.4**
Red River Chert	12.7	8.6	8.3	17.7	17.3
Silicified Wood	0.2	-	0.3	0.1	0.7
Swan River Chert	42.1	58.2	45.8	37.0	42.4
West Superior Materials	**0.7**	**1.4**	**0.4**	**1.1**	**0.2**
Animikie Group (*not specified*)	-	-	-	-	-
- Biwabik Silica	-	-	-	-	-
- Gunflint Silica	0.1	-	0.1	0.1	-
- Jasper Taconite	0.1	-	0.1	0.1	0.2
- Kakabeka Chert	-	0.1	-	-	-
Fat Rock Quartz					
Hudson Bay Lowland Chert	0.5	1.4	0.1	0.9	-
Lake Superior Agate	-	-	-	-	-
Pipestone Materials	**-**	**-**	**-**	**-**	**-**
Hollandale Materials	**1.5**	**-**	**2.2**	**0.6**	**1.6**
Cedar Valley Chert	0.2	-	0.4	0.1	-
Galena Chert	0.3	-	0.5	0.1	0.2
Grand Meadow Chert	0.3	-	0.5	0.1	0.9
Prairie du Chien Chert	0.6	-	0.8	0.3	0.5
Shell Rock Chert	-	-	-	-	-
Tongue River Silica	**9.1**	**1.4**	**12.6**	**5.8**	**5.2**
Border Lakes Greenstone Group	**2.8**	**15.0**	**2.2**	**3.1**	**1.1**
Knife Lake Siltstone	1.1	15.0	0.7	1.0	0.2
Lake of the Woods Siltstone	0.5	-	0.1	0.9	0.5
Lake of the Woods Rhyolite	1.2	-	1.4	1.2	0.5
Sioux Quartzite Group	**-**	**-**	**-**	**-**	**-**
Western River Gravels Group	**-**	**-**	**-**	**0.1**	**-**
Quartz (*not specified*)	**6.4**	**0.9**	**4.3**	**9.1**	**5.9**
Other (*cf. chopping tool matls*)	**0.6**	**0.9**	**0.5**	**0.7**	**0.5**

Table 4-10. Intensity of lithic raw material use in the South Agassiz Resource Region, Upper Red Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

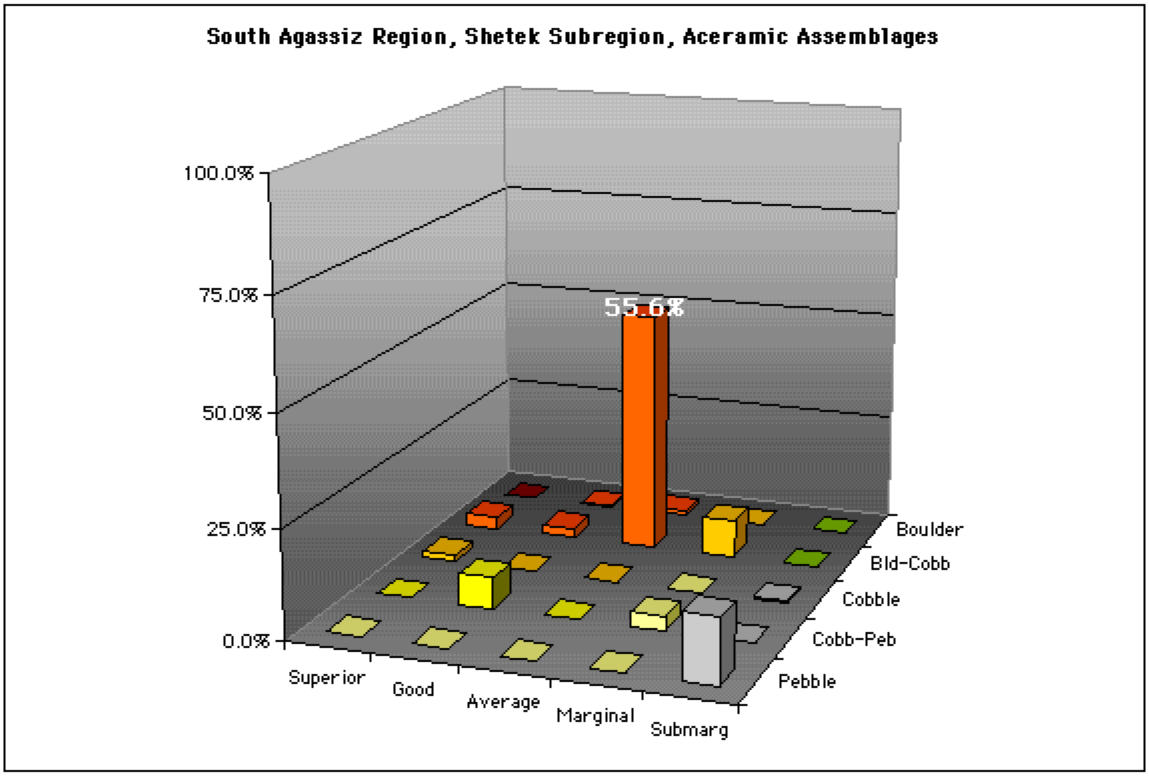
South Agassiz: Upper Red Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
Generic Identifications	**12.9**	**5.9**	**12.1**	**13.8**	**18.2**
Exotic Materials	**10.9**	**7.7**	**11.2**	**11.0**	**6.6**
Burlington Chert	-	-	0.1	-	-
Hixton Quartzite	0.2	-	0.5	-	-
Knife River Flint	10.6	7.7	10.6	10.9	6.6
Obsidian	0.02	-	-	0.06	-
Other Nonlocal Materials	**-**	**-**	**0.1**	**-**	**0.2**
Fusilinid Group	-	-	-	-	-
Maynes Creek Chert	-	-	-	-	-
Sample Size	*12,173*	*220*	*6,214*	*5,300*	*439*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample.

32RI775, Rustad

Rustad is a multicomponent site that was discovered in a soil quarry cut into a hillside above the Sheyenne River in Richland County, southeastern North Dakota. This falls in the Upper Red Subregion of the South Agassiz Resource Region. The site was investigated over multiple seasons in the 1990s. It is located on the edge of the Sheyenne delta and overlooking the lakebottom plain of Glacial Lake Agassiz. At this location, archaeological deposits were found in soils that developed in the lakebottom sediments, in overlying alluvial sediments that washed down from the Sheyenne delta uplands, and in aeolian deposits that later capped the alluvium. Artifacts and features were mostly associated with several paleosols that had developed during periods of extended stability. Although multiple and often clearly distinguished components were present, the most abundant remains were Early Archaic in age; it is the Early Archaic data that are reviewed here. A series of radiocarbon dates span the period of about 7,200 to 7,700 BP, with the most intensive occupation dating to about

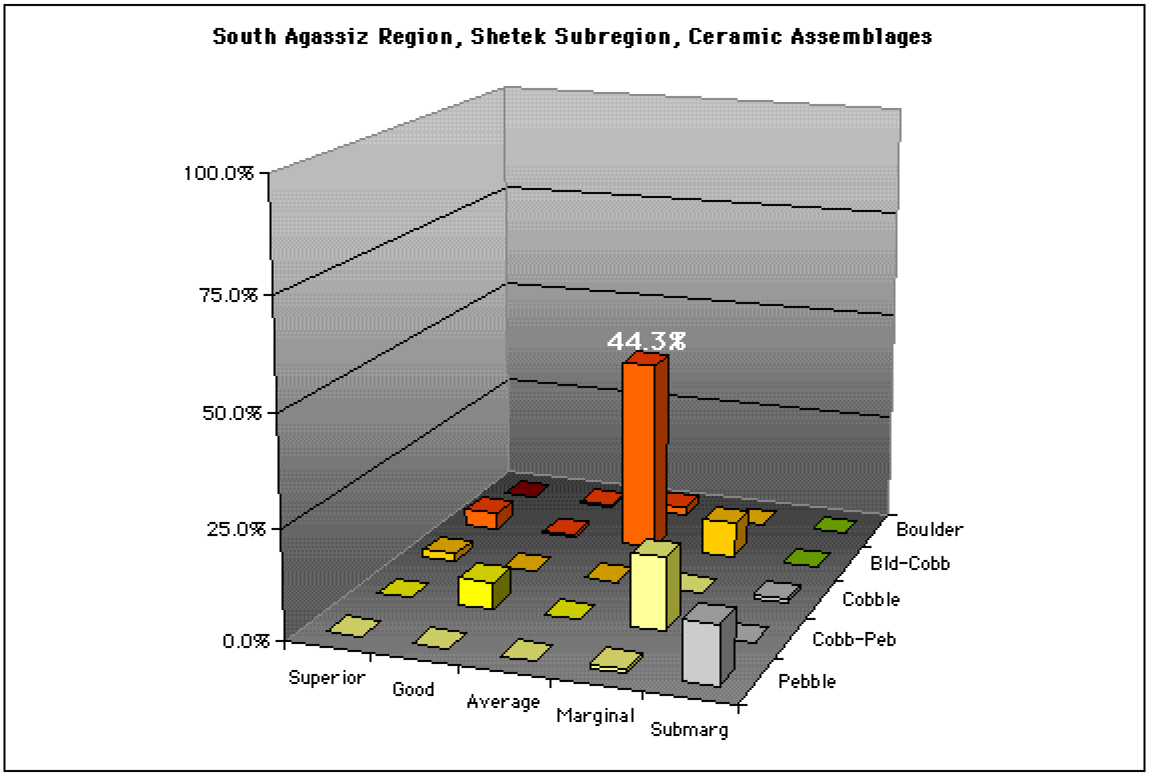
Figure 4-19. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the Shetek Subregion, South Agassiz Resource Region.



7,600 BP. Logan Creek/Mummy Cave and Delong projectile point also indicate an Early Archaic age for these components (Michlovic and Running 2003). The site was used repeatedly, and the discovery of remains of a structure indicates at least some duration of use during one habitation.

Swan River Chert constitutes the majority of this assemblage (%=76.3, or 5,332 of 6,985 pieces; Appendix 2: 32RI775). Red River Chert (%=7.3, n=510) is the second most common material, but note that the ratio of SRC to RRC is about 10 to 1. Knife River Flint is present (%=5.5, n=384), but in relatively small amounts for an assemblage from southeastern North Dakota. Other materials are present in very small amounts, including Tongue River Silica. Also note the relatively high percentage of unidentified or uncategorized materials (%=10.7, n=746). This number is higher than expected because the available raw material inventory for the site includes an "other" category that subsumes a number of identified but minor raw materials.

Figure 4-20. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the Shetek Subregion, South Agassiz Resource Region.



In an assemblage like this, we see that SRC is still an important raw material and is still intensively used. Note that it is distinctly lower, however, than the 90-plus percent levels seen in Paleoindian assemblages in the region. Note also the greater raw material diversity. The Paleoindian assemblages typically consist mostly of one raw material, wile Rustad consists of more than a dozen raw materials. The limited use of TRS is also interesting, since the aggregate data reviewed above indicates that TRS is more important in later assemblages. Its limited use in this assemblage suggests the possibility that TRS was largely avoided in this region and time period (in contrast with the Pipestone region, as discussed in connection with 13CK405 above).

47GT25, Bass

The Bass site is a lithic quarry and workshop site on a loess-covered upland ridge in Grant

County, in the southwestern corner of Wisconsin. This falls in the Hollandale Resource Region. At this location, Galena Chert is present in lag deposits that are buried by Pleistocene loess but also locally exposed by the erosion of headwater stream channels. The site was investigated in the mid 1970s to early 1980s. The investigators concluded that it was a single-component, Early Archaic site associated with production of Hardin Barbed projectile points (Stoltman et al. 1984). They posit use of the site during the period of about 8,000 to 10,000 BP, and probably more specifically in the period of 8,000 to 8,500 BP. The authors also note, however, that this chronology is principally derived from the perceived relationship between the Paleoindian Scottsbluff style and the later Hardin Barbed, and the possible evolution of the former into the latter. In fact, they note the recovery from the Bass site of two point bases that resemble the Scottsbluff type.

In terms of flaking quality, it is interesting that the authors note that "Galena Formation cherts are not of notably high quality" and that "in terms of knapping characteristics, it is of mediocre quality. They further note that "flaws and weathering fractures are common, so that blocky fragments abound" (Stoltman et al. 1984: 200, 202). Unfortunately, there is no information on package size.

It is also interesting to note the pattern of core reduction observed at the site:

> Examination of the cores indicates a uniform and simple technology of flake production. With few exceptions, all cores can be assigned to an amorphous, multifacial type, characterized by one or more discontinuous edges from which a few flakes were detached.... Apparently nodules were selected on the basis of suitable size and shape and then were unceremoniously bludgeoned wherever edge angles permitted easy flake extraction. [Stoltman et al. 1984:209]

This is in contrast to the type of formal core form and carefully planned reduction described above (Paleoindian Data) for the Beauty Lake site. The authors also note the production of bifaces, especially of Callahan's (1979) Stage 2.

The investigators subdivided the site into a number of areas; the data discussed here come from Area A. In this subsample, a total of 75,324 lithic artifacts were Galena Chert, and 19 were other raw materials. The result looks very like the kind of use pattern seen in the Paleoindian assemblages – even though we know that this is an Early Archaic assemblage. The simplest explanation for this is that Bass simply reflects raw material extraction from a primary-context, single-material source.[1] In this respect it generally resembles Bradbury Brook, which is of course a site with a Paleoindian profile. (Note, however, that the glacial sediments at Bradbury offered more than one type of raw material, but that Knife Lake Siltstone was the one chosen.)

13HA385, Allen Fan

Allen Fan is a multicomponent site in an alluvial fan along the Iowa River in Hardin County, central to north-central Iowa. The site is located near the intersection of three geophysical areas, the Des Moines lobe, the Iowan Surface, and the Southern Iowa Drift Plains (see Prior 1976). This falls on the border between the South Agassiz Resource Region (Shetek Subregion) and Hollandale Resource Region. The near-surface Late Archaic component was more lightly sampled, and produced a calibrated radiocarbon date of 790 B.C. (Fishel 2003b:63). The component is generally interpreted as a habitation. The flaked stone artifact sample from this component totaled 415 pieces; the sample included Late Archaic Table Rock points. The buried Middle Archaic component was more intensively sampled, and produced a calibrated radiocarbon date of about 5820 B.C. (Fishel 2003b:63). The component is interpreted as a fall deer-processing location. The flaked stone artifact sample totaled 5,230 pieces. The investigators interpret the site as the remains of two short-term episodes, the first of which mostly used local lithic raw materials extracted from till where it was eroded by the nearby stream. The second, in contrast, made greater use of raw materials from distant sources in southeastern Minnesota and southeastern Iowa (Fishel 2003a, 2003b; Fishel and Collins 2003).

Varieties of Maynes Creek Chert are the most abundant raw materials in both components, totaling 65.4 percent of the Middle Archaic assemblage and 52.3 percent of the Late Archaic assemblage (Appendix 2: 13HA385). The Maynes Creek Dolomite outcrops in multiple locations in Hardin County (Collins 2003), making Maynes Creek Chert a local raw material. Other raw materials from nearby sources also contribute significantly to the assemblages. It is interesting to note, however, that nonlocal and extraregional raw materials are better represented in the Middle Archaic component (%=19.7) than in the Late Archaic component (%=10.3). This includes a few pieces of a Fusilinid Group material in the Middle

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[1] In strict geologic terms, the Galena Chert lag deposits are secondary. For the purposes of this analysis, however, they are in close proximity to the place of origin and are better classified as primary.

Table 4-11. Intensity of lithic raw material use in the West Superior Resource Region, Arrowhead Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

West Superior: Arrowhead Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
South Agassiz Materials	**0.2**	**-**	**0.9**	**1.0**	**-**
Red River Chert	-	-	0.2	0.1	
Silicified Wood	-	-	-	-	
Swan River Chert	0.2	-	0.7	0.9	
West Superior Materials	**18.5**	**7.8**	**53.8**	**52.4**	
Animikie Group (*not specified*)	2.4	-	19.3	1.7	
- Biwabik Silica	-	-	-	-	
- Gunflint Silica	6.6	1.2	22.3	25.6	
- Jasper Taconite	5.6	5.6	5.4	6.1	
- Kakabeka Chert	0.7	0.3	3.3	0.6	
Fat Rock Quartz					
Hudson Bay Lowland Chert	3.1	0.7	3.3	18.3	
Lake Superior Agate	-	-	0.2	-	
Pipestone Materials	**-**	**-**	**-**	**-**	
Hollandale Materials	**-**	**-**	**0.1**	**-**	
Cedar Valley Chert	-	-	-	-	
Galena Chert	-	-	0.1	-	
Grand Meadow Chert	-	-	-	-	
Prairie du Chien Chert	-	-	-	-	
Shell Rock Chert	-	-	-	-	
Tongue River Silica	**0.1**	**-**	**0.8**	**0.3**	
Border Lakes Greenstone Group	**66.0**	**82.1**	**16.6**	**11.2**	
Knife Lake Siltstone	64.4	81.3	8.8	9.9	
Lake of the Woods Siltstone	-	-	-	-	
Lake of the Woods Rhyolite	1.6	0.8	7.8	1.3	
Sioux Quartzite Group	**-**	**-**	**-**	**-**	
Western River Gravels Group	**-**	**-**	**-**	**-**	
Quartz *(not specified)*	**7.9**	**3.3**	**20.7**	**25.2**	
Other *(cf. chopping tool matls)*	**2.4**	**2.5**	**3.5**	**0.4**	

Table 4-11. Intensity of lithic raw material use in the West Superior Resource Region, Arrowhead Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

West Superior: Arrowhead Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
Generic Identifications	**3.9**	**4.3**	**2.2**	**2.8**	
Exotic Materials	**1.0**	**-**	**1.3**	**6.6**	
Burlington Chert	-	-	-	-	
Hixton Quartzite	0.1	-	-	0.9	
Knife River Flint	0.8	-	1.3	5.7	
Obsidian	0.01	-	-	0.05	
Other Nonlocal Materials	**-**	**-**	**-**	**-**	
Fusilinid Group	-	-	-	-	
Maynes Creek Chert	-	-	-	-	
Sample Size	*18,094*	*13,853*	*2,028*	*2,203*	*0*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample.

Archaic assemblage (%=0.1), but none in the Late Archaic assemblage. (Note that neither assemblage includes any Knife River Flint, an observation that gains significance in light of evidence of Middle to Late Archaic components at sites farther to the north.) Correspondingly, materials probably derived from glacial till are lower in the Middle Archaic component (%=2) than in the Late Archaic assemblage (%=14). The difference in quartz use might also be pointed out. In the Middle Archaic assemblage, the figure is 0.2 percent, while in the Late Archaic it is 6.3 percent.

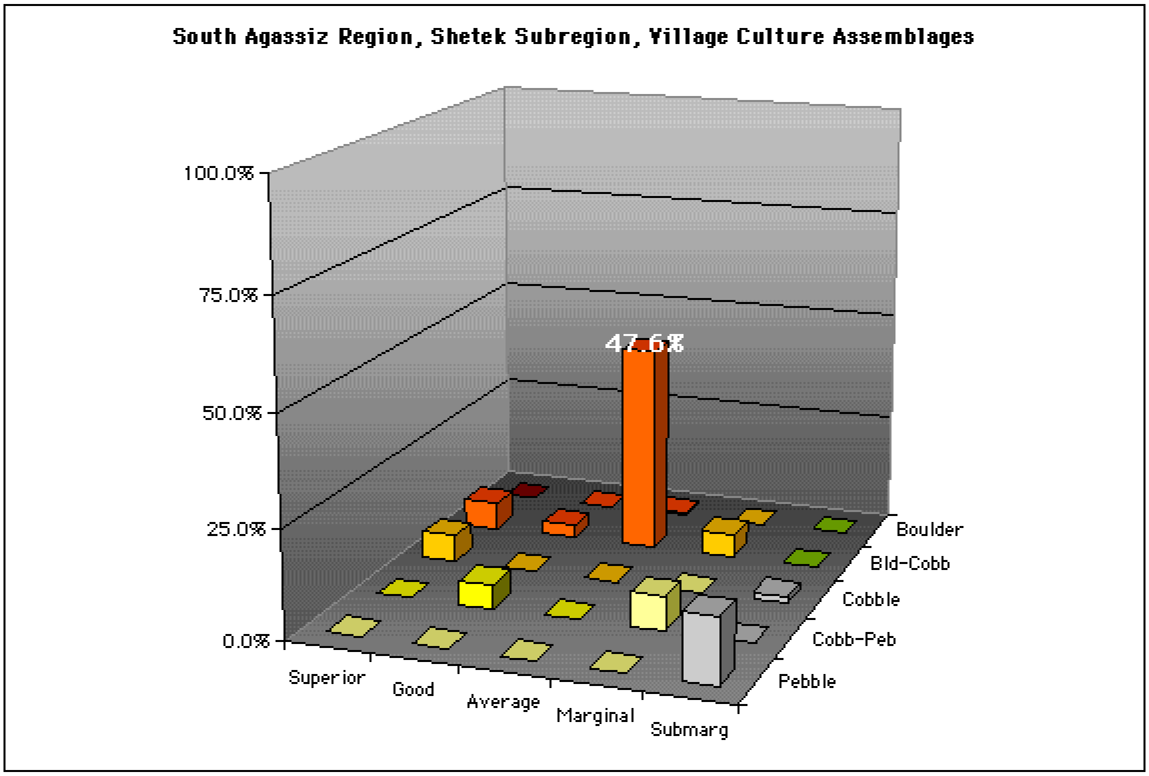
We can attempt an interpretation of the differences between these assemblages, specifically in light of the evidence from the Cherokee site discussed above (Paleoindian Data), with the understanding that this is again a provisional hypothesis to be re-examined in light of evidence from additional sites and assemblages. At Cherokee we seem to see a near collapse of raw material circulation with the advent of the Early Archaic, then the rebuilding of raw material circulation by the Middle Archaic. Recall the evidence of Fusilinid Group cherts in particular, which constituted 0.2 percent of the Early Archaic assemblage and 48.8

percent of the Middle Archaic assemblage. While the percentage of extralocal raw materials at Allen Fan in the Middle Archaic is much lower (%=19.7), this could still represent a high point in raw material circulation during that time period. (Note in particular the presence of a Fusilinid Group chert in the Middle Archaic sample, and its absence from the Late Archaic sample.) The differences in percentage between Cherokee and Allen Fan might conceivably be explained by nearby access to bedrock sources at the Allen Fan site, and the dependence on glacial sediment sources at Cherokee.

Allen Fan suggests that in addition to minimal raw material circulation in the Early Archaic and a rebuilding of substantial circulation by the Middle Archaic, we might posit a diminishment of circulation by the end of the Late Archaic. This fall-off in circulation, however, would not be to the degree seen in the Early Archaic. In addition, the change in till-derived materials at Allen Fan between the Middle (%=2) and Late (%=14) Archaic assemblages offers a possible clue that the Late Archaic use of local raw materials focuses on a broader range of raw materials compared to Early Archaic use. If that was to prove the case, then Late Archaic assemblages might bear an increasing resemblance to subsequent ceramic-period assemblages (discussed below).

In addition to the caveat that this is a tentative hypothesis, I would like to add two other cautionary statements to the consideration of changes in raw material circulation during the Archaic. First, we need to consider that such changes may well be regional, and that the history of raw material circulation in one region does not necessarily match that of another region. Although I suspect that a great drop in circulation at the beginning of the Archaic may well be widespread, later changes may not be. We can see a specific example with the presence of Knife River Flint at sites to the north and northwest of Cherokee and Allen Fan. There the evidence from multiple sites shows a clear increase in the abundance of KRF all the way to the end of the Archaic, when it reaches a clear peak. Second, we need to consider that different raw materials may have their own unique histories when it comes to extent and intensity of circulation, almost independent of overall regional trends, and that we need to separately and specifically examine this history of circulation for each raw material. In this case I am not thinking of every raw material in the greater region, but of the exotics plus a number of important regional materials that tended to circulate is noticeable quantities outside of their native resource regions. The former include Burlington Chert, Hixton Quartzite, Knife River Flint and obsidian. Examples of the latter might include such materials as Prairie du Chien Chert, the Fusilinid Group materials, Cedar Valley Chert, Grand Meadow Chert, Fat Rock Quartz and possibly others. I doubt that there would be much to

Figure 4-21. Utility analysis XYZ depiction of aggregated village culture assemblage data from the Shetek Subregion, South Agassiz Resource Region.

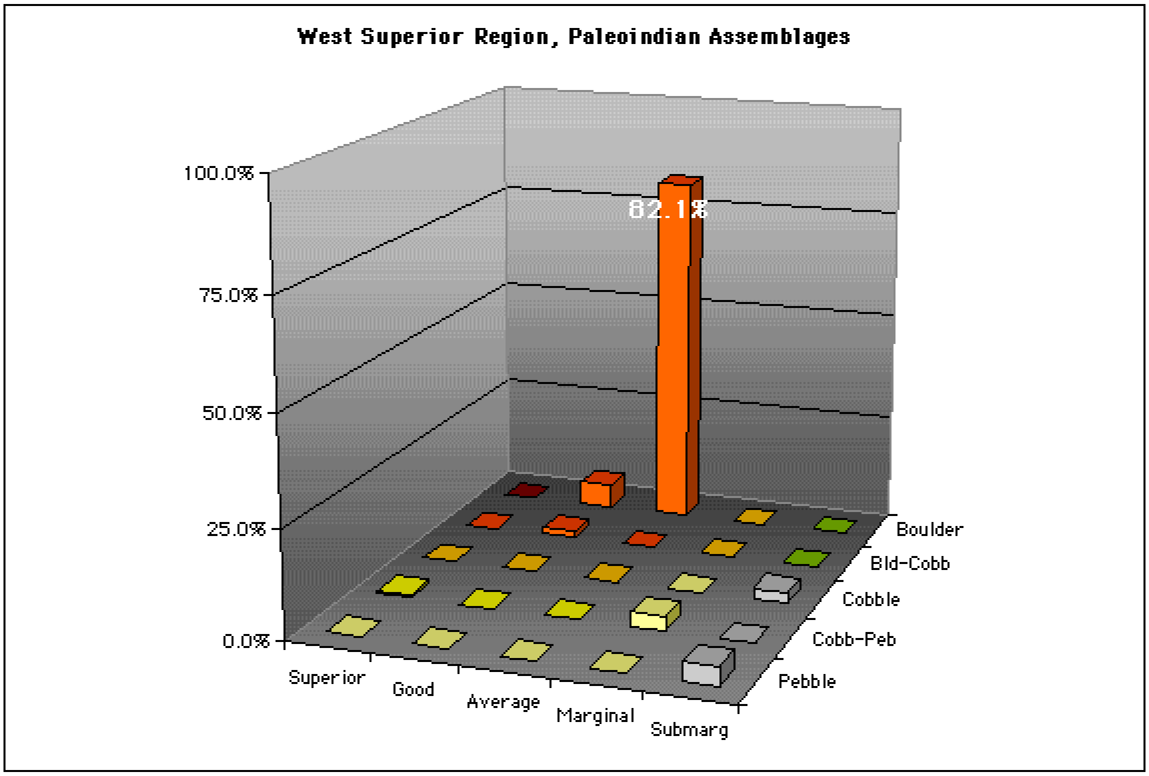


learn from trying to construct individual histories for the less desirable raw materials (Tongue River Silica comes to mind), although perhaps they should not be excluded out of hand.

21NR9, Canning

The Canning site is located on the bank of the Red River near Halstead in Norman County, west-central Minnesota. This falls in the Upper Red Subregion of the South Agassiz Resource Region. Deposition from the Red River has produced deep fluvial sediments in some areas along the river, including at the Canning site. At this location, an upper Late Woodland component overlay a Late Archaic bison kill or butchering site. A set of radiocarbon dates on the lower component could not be entirely reconciled, but placed the component somewhere in the interval of 3,000 to 4,000 BP. A date of 3340 ± 170 was obtained for bison bone from the bone bed, and this date may be the most securely associated with the

Figure 4-22. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the West Superior Resource Region.



excavated component. Note also, however, that charcoal from a diffuse stain of charcoal, burnt bone and flakes was dated to 4330 ± 115 (Michlovic 1986).

This site is located at the center of the southern Lake Agassiz basin. In this vicinity, deep lacustrine sediments overlie earlier glacial sediments, and the local landscape is essentially rock free. The nearest source of toolstone was likely the Lake Agassiz beaches many miles to the east and west. This produces an interesting situation in terms of toolstone provisioning and the resulting raw material samples. All lithic artifacts found on sites in this context should have been carried to the site, and we might be safe in thinking that these were brought to the site principally in the form of finished tools, preforms, or flake blanks. If this was the case, we should see little flaking debris that is associated with the earlier stages of procurement such as cobble testing, decortication or core preparation. How this might effect the raw material composition of an assemblage is not presently clear, but the topic might be worth further examination in the future.

Table 4-12. Intensity of lithic raw material use in the West Superior Resource Region, Quartz Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

West Superior: Quartz Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
South Agassiz Materials	**12.0**	**4.3**	**8.1**	**12.3**	
Red River Chert	2.0	3.7	0.8	2.0	
Silicified Wood	-	-	-	-	
Swan River Chert	10.0	0.6	7.3	10.2	
West Superior Materials	**6.8**	**1.9**	**4.4**	**6.9**	
Animikie Group (*not specified*)	0.1	-	-	0.1	
- Biwabik Silica					
- Gunflint Silica	1.4	0.6	0.8	1.4	
- Jasper Taconite	2.5	1.2	2.8	2.5	
- Kakabeka Chert	-	-	0.3	-	
Fat Rock Quartz					
Hudson Bay Lowland Chert	1.3	-	0.1	1.4	
Lake Superior Agate	1.5	-	0.4	1.6	
Pipestone Materials	**-**	**-**	**-**	**-**	
Hollandale Materials	**2.4**	**0.6**	**4.1**	**2.3**	
Cedar Valley Chert	0.2	-	-	0.2	
Galena Chert	0.1	-	0.2	0.1	
Grand Meadow Chert	0.1	-	0.4	0.1	
Prairie du Chien Chert	2.0	0.6	3.5	1.9	
Shell Rock Chert	-	-	-	-	
Tongue River Silica	**13.7**	**-**	**22.4**	**13.3**	
Border Lakes Greenstone Group	**6.1**	**80.2**	**7.6**	**5.6**	
Knife Lake Siltstone	4.4	80.2	5.1	4.0	
Lake of the Woods Siltstone	-	-	-	-	
Lake of the Woods Rhyolite	1.6	-	2.5	1.6	
Sioux Quartzite Group	**-**	**-**	**-**	**-**	
Western River Gravels Group	**0.1**	**-**	**-**	**0.1**	
Quartz *(not specified)*	**45.6**	**8.0**	**46.0**	**45.8**	
Other *(cf. chopping tool matls)*	**1.7**	**-**	**0.3**	**1.7**	

Table 4-12. Intensity of lithic raw material use in the West Superior Resource Region, Quartz Subregion by approximately-chronological aggregation of assemblages. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

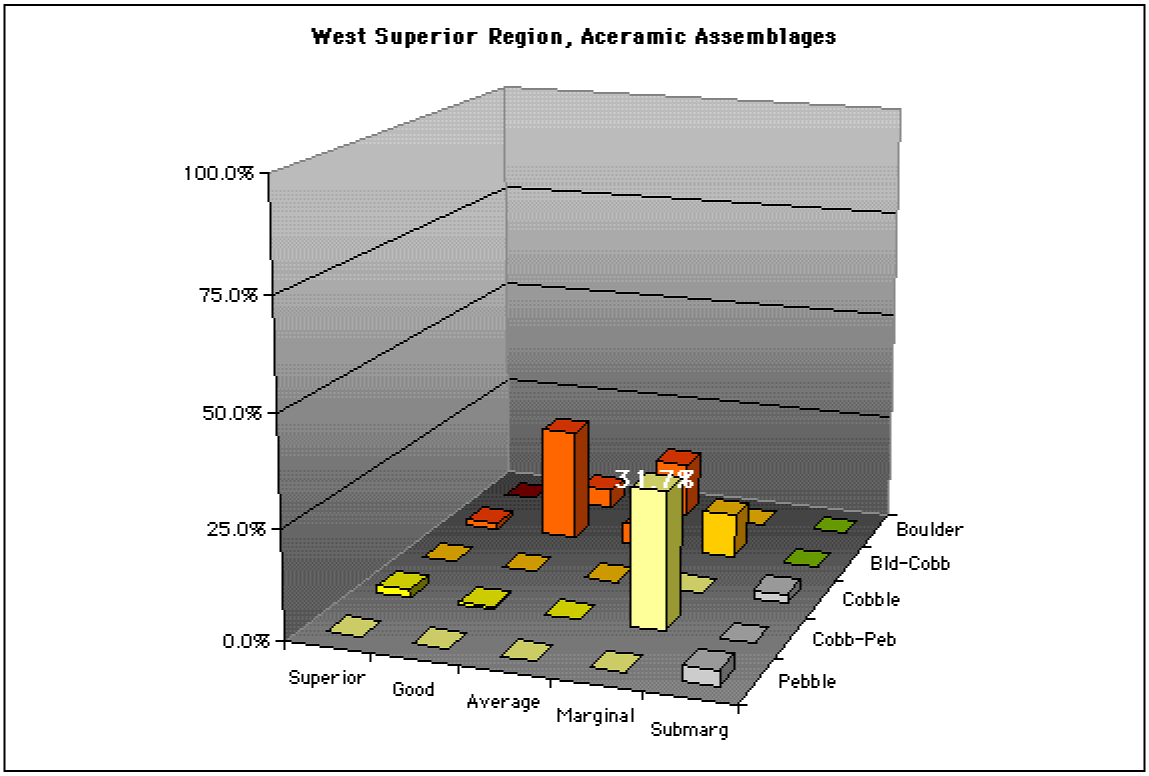
West Superior: Quartz Subregion	**All**	*cf. Paleo*	*Aceramic*	*Ceramic*	*cf. Village*
Generic Identifications	**8.6**	**3.1**	**5.3**	**8.8**	
Exotic Materials	**3.1**	**1.9**	**1.8**	**3.1**	
Burlington Chert	0.3	1.2	-	0.3	
Hixton Quartzite	0.4	0.6	0.7	0.3	
Knife River Flint	2.3	-	1.1	2.4	
Obsidian	0.12	-	-	0.12	
Other Nonlocal Materials	**-**	**-**	**-**	**-**	
Fusilinid Group	-	-	-	-	
Maynes Creek Chert	-	-	-	-	
Sample Size	*32,569*	*162*	*1,554*	*30,765*	*0*

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample.

As with most assemblages in the South Agassiz Resource Region, Swan River Chert remains the single most important raw material (n=563 of 1196; %=47.1; Appendix 2: 21NR9). While this number is still high, it is much lower than the kinds of figures seen in regional Paleoindian assemblages, and still lower than the figure seen in a nearby Early Archaic assemblage like Rustad (%=76.3). The second most important materials at Canning, however, is Knife River Flint (%=29.8), as opposed to Red River Chert at Rustad (%=7.3). This is a fairly high number for an exotic from a relatively distant source, and substantially above the 5.5 percent KRF seen at the Early Archaic Rustad site. This is an indication of the importance of KRF in Late Archaic assemblages in eastern North Dakota and the Red River Valley, an observation that is reinforced by data from some of the assemblages examined below. It is also an important point to bear in mind when considering the history of the circulation of KRF.

The contrast between Canning and Rustad also begins to point to an interesting observation, one that might seem obvious in hindsight. At a site like Rustad, we see mostly

Figure 4-23. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the West Superior Resource Region.



local provisioning and the use of a range of raw materials; KRF represents only an "accent" to provisioning. At a site like Canning, however, rising levels of KRF use result in a contraction, so to speak, of local provisioning. SRC continues in use because it is the most important local toolstone in terms of abundance and flaking quality; it continues in use although the intensity of use diminishes somewhat. Other materials tend to fall out of use more quickly. We might posit that the lower its flaking quality or the smaller its size, the sooner a raw material will be devalued in provisioning. This is an that we can bear in mind as we look at other assemblages with high percentages of Knife River Flint, or at later period assemblages with potentially greater diversity in toolstone provisioning.

Before we move on to another assemblage, it is worth briefly considering the later assemblage from Canning. This is a small (n=47) set from a surface and near surface Sandy

Lake (Late Woodland) component.[2] Swan River Chert is the most common raw material in this assemblage (%=57.4), with Tongue River Silica the second most common material (%=10.6). Both of these numbers are similar to the ones seen in the earlier Archaic assemblage. The numbers in the Sandy Lake assemblage are distinctly higher for Red River Chert (%=12.8) and quartz (%=6.4), while Knife River Flint is represented by a single piece (%=2.1). Thus in the later assemblage, the importance of KRF is much diminished, while the importance of the local materials RRC and quartz is much increased (and note that both of these occur in the cobble-pebble package size range). The pattern associated with the Woodland assemblage does seem to be distinct from the pattern seen in the Archaic assemblage; we will further consider the potential significance of such differences in the review of ceramic and Woodland assemblages below.

Polk County, Minnesota Flood Control Investigations Sites

After catastrophic flooding of the Red River in 1997, the U.S. Army Corps of Engineers instituted a series of flood control projects in the cities of Grand Forks, North Dakota and East Grand Forks, Minnesota. This resulted in multiple archaeological surveys over a period of several years, and the discovery of many archaeological sites. Along much of the Red River (and its tributaries near their confluences with the Red), sites are concentrated along the river where overbank flooding has built up the landscape over the course of millennia and produced many buried paleosols and stratified, multicomponent sites. The flood control surveys resulted in the discovery of several such sites, many with associated radiocarbon dates. The close location of the sites to each other means that, in general, the inhabitants should have access to the same lithic resources and we are thus able to control for this factor, at least to some degree. The variation that we see between assemblages is therefore more likely to represent cultural factors, and changes in raw material use through time.

The assemblages we will examine include 21PL49 (Prairie Archaic, Late Prehistoric; Florin and Wergin 2001; Florin et al. 2001), 21PL54 (Prairie Archaic, Middle Woodland; Florin et al. 2001), 21PL57 (Middle to Late Plains Archaic, Late Plains Archaic; Florin et al. 2001), 21PL66 (Middle Woodland; Florin et al. 2001), 21PL72 (Middle Woodland; Harvey et al. 2005), 21PL74 (Middle Woodland, two components taken together; Harvey et al.

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[2] The published report (Michlovic 1986) indicates a somewhat higher count for the upper assemblage. The figures I am using here come from my own inventory of the Canning artifacts.

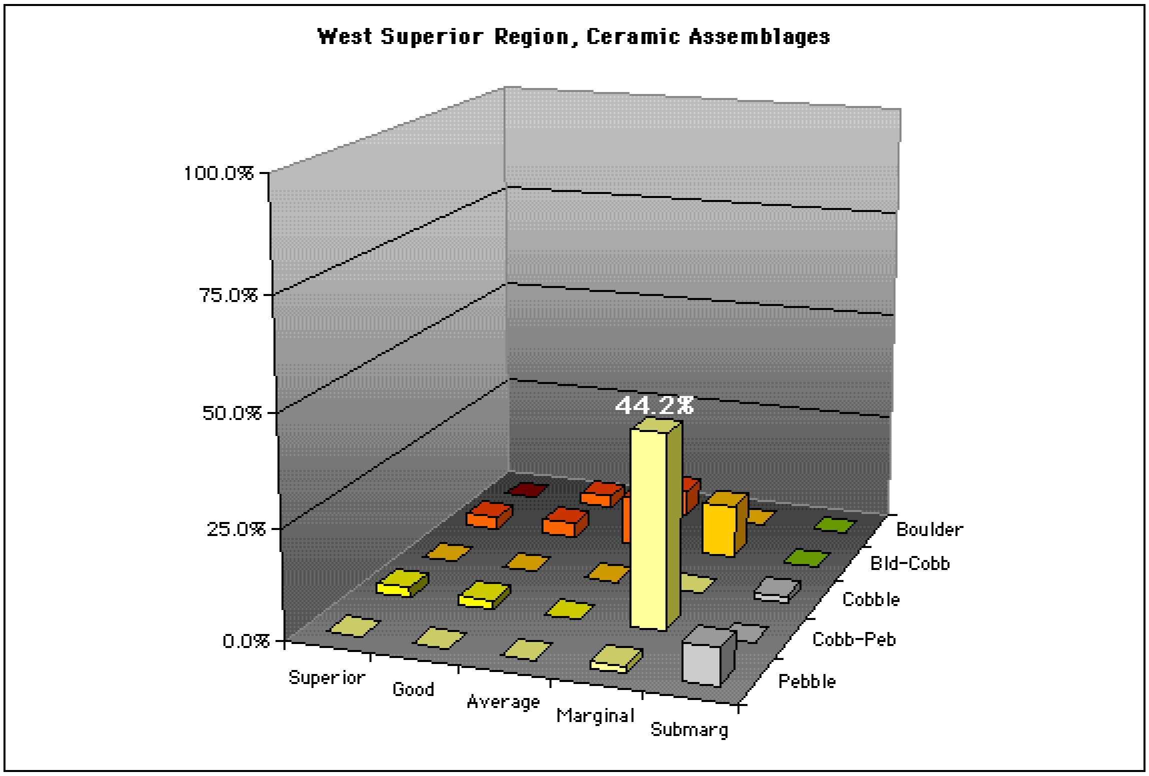
2005), 21PL83 (lower, possibly Sandy Lake; Florin and Wergin 2004), and 21PL85 (middle, lower; Florin and Wergin 2004). Although some of the components have small lithic samples, they are included because they are dated, or come from multicomponent sites, or both. A number of other sites and assemblages are not included if they include small lithic assemblages, are undated, or lack lithic artifacts. The sites are all located in broadly similar landscape settings near the Red River, or along the Red Lake River near its confluence with the Red River. Interpreted functions varies somewhat, but all are likely camps of limited size and duration or are hunting related. Since the set of assemblages is about evenly divided between Archaic and Woodland samples, they are introduced here in the context of discussing Archaic and aceramic evidence, and then referred to again in the following section where ceramic, Woodland period evidence is reviewed.

Table 4-19 provides a summary of selected data for these sites and assemblages. This includes associated radiocarbon dates, sample size, and percentages for Swan River Chert, Red River Chert, Knife River Flint, and quartz. SRC is included because it is the most important local toolstone. RRC is included because it is also commonly used, and its intensity of use seems sensitive to the level of KRF use. KRF is included, of course, because we are interested in seeing what we can learn about fluctuating levels of use through time. Quartz is included because it might prove to be an indicator of changing raw material use patterns.

Since 21PL57 includes two Archaic components and the bulk by count of the Archaic data, we will begin by discussing this site in somewhat greater detail than the other sites. The two assemblages from 21PL57 offer us a chance to take a further look at potential changes in the prevalence of KRF through the Archaic. Two Archaic components were sampled at the site. The lower one yielded a relatively small lithic sample (n=27), but this still provides a useful point of comparison with the upper component. One sample of bone collagen provided a date of 3640 ± 40 BP, placing this in the Late Archaic. The upper component yielded a larger lithic assemblage (n=433). Two samples of bone collagen provided dates of 3170 ± 40 BP and 3220 ± 40 BP, also placing this assemblage securely in the Late Archaic.

Knife River Flint constitutes 40.7 percent of the lower component, an even higher percentage than seen in the Archaic component at Canning (Appendix 2: 21PL57). The assemblage also contains a single piece of Prairie du Chien Chert (%=3.7); unfortunately the remainder of the assemblage (n=15) was not identifiable. Although the percentage of KRF in the lower component seems quite high on first glance, it pales in comparison with the upper component where KRF constitutes 84.8 percent (n=367) of the assemblage. Most of the remainder of the upper component consists of Swan River Chert (n=60, %=13.9), with small

Figure 4-24. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the West Superior Resource Region.



amounts of basaltic rock and unidentified materials. These figures present a second hint that KRF circulation increases significantly during the Late Archaic, and in particular for sites within the Lake Agassiz lakebottom plane and along the Red River. Note that these figures hint that while the intensity of KRF use might have been rising throughout the Late Archaic (or possibly earlier), there may be a dramatic increase near the end of the Late Archaic, shortly before 3000 BP. While the evidence reviewed here is not adequate to establish such a trend, the possibility should be borne in mind in reviewing other data from the region and period. In addition, we see again that the rising levels of KRF use diminish levels of use for local raw materials, beginning with the smaller or poorer quality raw materials, and then diminishing the use of the local mainstay Swan River Chert.

21PL54 provides an interesting contrast. Note that the lower component here is similar in age to Rustad, and that it also contains a relatively small percentage of KRF (%=10.0; Appendix 2: 21PL54). Compare this with the upper, Middle Woodland component at the same site, where KRF constitutes 57.0 percent of the assemblage. Finally, a small Middle Archaic lithic sample from 21PL49 includes only generically identified or unidentified raw materials, making it of limited use in interpreting this series of assemblages.

Overall, the impression created by this series of assemblages is of low intensity KRF use in the Early Archaic, with levels rising possibly through the Middle Archaic and definitely in the Late Archaic. KRF use reaches an impressive peak in the terminal Late Archaic. Use remains high in the Middle Woodland, although not as high as in the Late Archaic. The intensity then appears to drop off with the transition to the Late Woodland.

With such an apparent trend in mind, it is tempting to try to place the undated Archaic assemblage from 21PL85 in the sequence. Since the assemblage from 21PL85 has a very high percentage of KRF (%=96.6; Appendix 2: 21PL85), it would seem most at home in the very Late Archaic with an assemblage like the one from the upper component at 21PL57 (%=84.8). It could be, of course, that there is a sampling problem since 43 of the 59 lithic artifacts come from a feature, and since the artifacts are small and likely associated with tool maintenance. It certainly is possible that the flakes related to maintenance of one or two tools, which by happenstance were made of KRF. Bear in mind, however, that the more important KRF is a given assemblage, the more likely the one or two resharpened tools are likely to be KRF and thereby produce the kind of assemblage observed in this case.

We should be clear that such an exercise is premature at this point (although it offers a sense of what we might be able to accomplish, given additional evidence and study). We should also be clear about a couple of other caveats. First, the small sample size for many of these assemblages compromises our ability to do dependable utility analysis, much less age estimation. Second, any such age estimation can only be approximate, given that other factors will certainly also influence the levels of KRF in any given assemblage; the issue of the feature context provides one example. Even so it would still be helpful to be able to argue, for example, that an undated aceramic assemblage might date to late in the Archaic based on high levels of KRF, rather than only being able to say that it is aceramic and earlier than the overlying Middle Woodland component. And if we could improve out understanding of both geographic and temporal variations in the intensity of KRF use, we might be able to refine our estimates.

32RI785

32RI785 is a multicomponent site located on the edge of a Glacial Lake Agassiz shoreline and

Table 4-13. Intensity of use for selected lithic raw materials for potential village culture assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Potential Village Culture Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
South Agassiz Materials	**7.4**	**57.3**			**0.6**
Red River Chert	1.8	14.7			0.1
Silicified Wood	0.1	0.5			-
Swan River Chert	5.5	42.1			0.5
West Superior Materials	-	**0.2**			-
Animikie Group (*not specified*)	-	-			-
- Biwabik Silica	-	-			
- Gunflint Silica	-	-			-
- Jasper Taconite	-	0.2			-
- Kakabeka Chert	-	-			-
Fat Rock Quartz					
Hudson Bay Lowland Chert	-	-			-
Lake Superior Agate	-	-			-
Pipestone Materials	**0.1**	**0.5**			**-**
Hollandale Materials	**65.3**	**4.1**			**73.7**
Cedar Valley Chert	0.7	-			0.8
Galena Chert	4.6	0.2			5.2
Grand Meadow Chert	18.2	2.1			20.3
Prairie du Chien Chert	41.3	1.8			46.8
Shell Rock Chert	-	-			-
Tongue River Silica	**0.6**	**5.3**			**-**
Border Lakes Greenstone Group	**0.1**	**1.1**			**-**
Knife Lake Siltstone	-	0.2			-
Lake of the Woods Siltstone	-	0.4			-
Lake of the Woods Rhyolite	0.1	0.5			-
Sioux Quartzite Group	**-**	**-**			**-**
Western River Gravels Group	**-**	**-**			**-**
Quartz (*not specified*)	**0.8**	**6.4**			**0.1**
Other (*cf. chopping tool matls*)	**0.2**	**0.7**			**0.1**

Table 4-13. Intensity of use for selected lithic raw materials for potential village culture assemblages. Figures indicate percentage of aggregated sample. A dash indicates absence, or occurrence at a frequency of less than 0.05 percent; a blank cell indicates that there are no data for that category.

Potential Village Culture Assemblages	**Minn (all)**	*South Agassiz*	*West Superior*	*Pipe-stone*	*Hollan-dale*
Generic Identifications	**11.5**	**17.0**			**10.8**
Exotic Materials	**13.7**	**6.5**			**14.7**
Burlington Chert	1.0	-			1.2
Hixton Quartzite	11.8	-			13.5
Knife River Flint	0.8	6.5			-
Obsidian	-	-			-
Other Nonlocal Materials	**0.1**	**0.9**			**-**
Fusilinid Group	-	0.2			**-**
Maynes Creek Chert	0.1	0.7			-
Sample Size	***4,704***	***565***	***0***	***0***	***4,139***

This table lists individual raw materials only if they occur at a frequency of at least 1.0 percent in one region or subregion; other materials occur but are not specifically listed. The entire sample is represented in the shaded rows; breakouts by individual raw materials include only part of the total sample. The "Minn Statewide" column includes data from counties that lie in more than one resource region; these counties are not included in the regional columns.

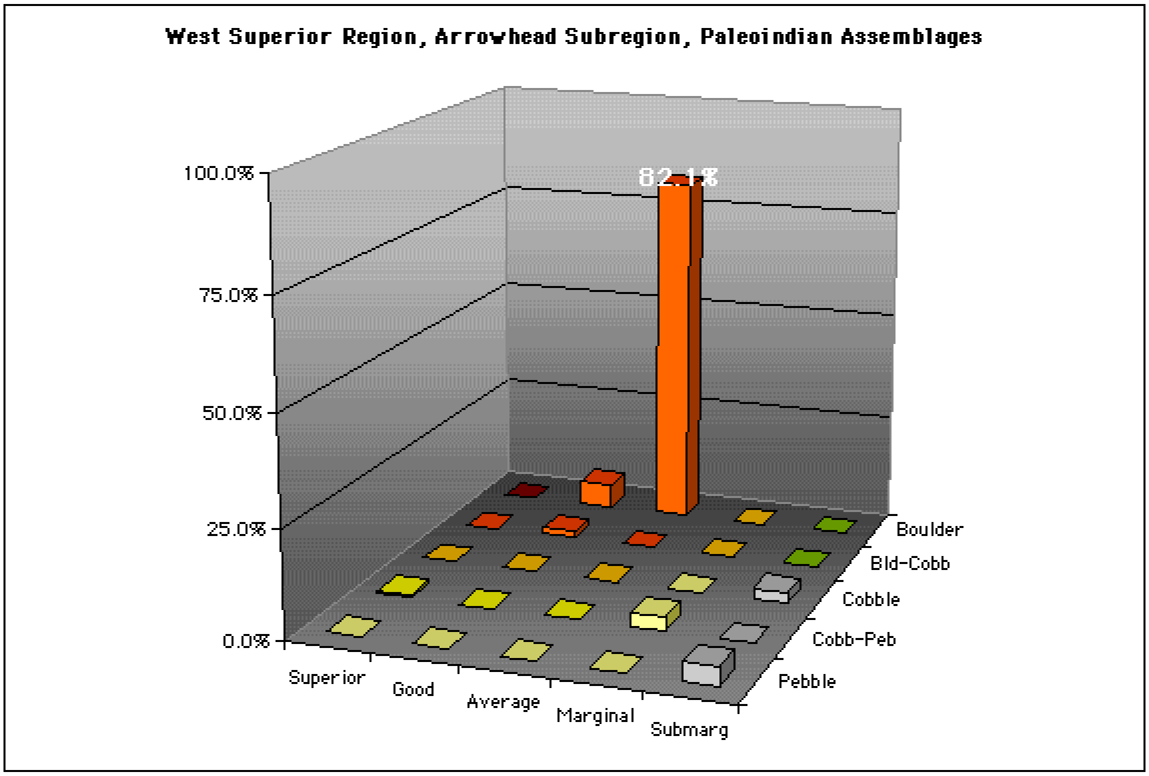
overlooking the Wild Rice River in southeastern-most North Dakota. This falls in the Upper Red Subregion of the South Agassiz Resource Region. The site was investigated over three seasons in the late 1990s. This discussion focuses on Block 8 on the west end of the site, where excavation encountered two components that were stratigraphically separated. These were an early Middle Plains Archaic component believed to represent one or more residential mobility camps, and a Late Plains Archaic component believed to represent a hunting field camp (Dobbs 2001). The ages of the components were based on projectile point typology. The investigators noted that although the two components were contained in different lithostratigraphic units, less than ideal field conditions and the close proximity of the components necessitated great care in separation of the components. Most of the lithic artifacts could be confidently assigned to one or the other component, but a few could not and were considered to represent a mixed assemblage. The following discussion examines only the pieces that were assigned to one or the other component.

Note that there may be one complication with raw material identification. The report discusses Cathead Chert, which is one component of the broader category Red River Chert. While the matter is not quite clear, it may be that the investigators did principally identify only Cathead Chert. Since the resulting numbers seem low compared to the levels of Red River Chert in comparable sites, and the numbers for generic "chert" seem high, this could indeed be the case. Thus the numbers for RRC and for unidentified and generically identified materials discussed below should be regarded as potentially problematic.

The investigators do note the differences in raw material composition between the two components, and discuss it at some length. The following description recapitulates their description in many ways, but with a different point of view based on the analytical perspective developed in this thesis. The principal identified raw materials in both assemblages are Swan River Chert and Knife River Flint (Appendix 2: 32RI785). The balance between them shifts significantly, however. In the Middle Archaic component, SRC constitutes 51.0 percent of the assemblage, while in the Late Archaic it constitutes only 20.9 percent. KRF shows almost the same figures but reversed. In the Middle Archaic component, it constitutes 16.8 percent of the assemblage, while in the Late Archaic it constitutes 56.0 percent. This offers support for the interpretation advanced in connection with the Polk County sites about the relative abundance of KRF in Late Archaic assemblages. This places 68.7 percent of provisioning in the UP-1 sector for the Middle Archaic assemblage, and 77.9 percent for the Late Archaic assemblage. This might serve as a reminder that while disposition of proveniencing in the utility plane offers useful insight on raw material use, it must be interpreted in the light of the contributing raw materials and their origins.

A comparison with the figures for KRF for the Early Archaic component at the nearby Rustad site is also instructive (Appendix 2: 32RI775). At Rustad, KRF constituted only 5.5 percent of the assemblage. The increase to 16.8 percent for the early Middle Archaic component at 21RI785 suggests that level of circulation of KRF might have been increasing through much of the Archaic and not just at the end of the Late Archaic. If this is the case, the levels of KRF in an Archaic assemblage might provide a useful way to estimate approximately where in the Archaic that assemblage belongs. Note that even if this is the case, such an estimate is likely to be more meaningful in eastern North Dakota, along the Red River, and possibly in parts of the Agassiz basin in west-central to northwestern Minnesota. There is a dropoff in percentage of KRF to the east (see, for example, Clark 1984), which is likely to make percentage of KRF a less sensitive indicator of chronological variation.

Figure 4-25. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the Arrowhead Subregion, West Superior Resource Region.



We may also note that TRS is present but only in very small amounts in both assemblages, as is quartz. The same is true of the nonlocal material Prairie du Chien Chert. Obsidian is absent from the Middle Archaic component, but occurs at a level of 0.7 percent in the Late Archaic component.

21MA62 and 21MA63, Middle River Gravel Lease IV and V

These sites are located on a Lake Agassiz beach and overlooking the Middle River, in Marshall County of northwestern Minnesota. This falls in the Tamarack Subregion of the South Agassiz Resource Region. Peterson (1998) proposed that the beach ridge served as a raw material source for this site and nearby sites located on this landform. These sites were investigated on multiple occasions in the 1990s in connection with a county road project and state DNR plans.

Work at 21MA62 included surface collection and the excavation of two adjacent 1 x 1 m excavation units. Excavation encountered a pit feature measuring about 50 by 50 cm and containing a bone concentration; the bone included part of an antler and a section of mandible, tentatively identified as caribou or juvenile moose. Artifacts (n=568) were found to a general depth of 45 cm below surface, and to a depth of 50 cm below surface in the bottom of the pit feature. Based on projectile points recovered from different parts of the sediment column, the researchers concluded that the lower levels of the site were Middle Archaic, the immediately subplowzone levels were Late Archaic, and the plowzone contained a Woodland component.

The 21MA62 profiles (Appendix 2: 21MA62) do provide some corroboration of this interpretation.[3] The importance of Swan River Chert is high in the 35 to 40 cm level (%=48), then falls to a low in the plowzone (%=33.7) before rising again in the surface collection (%=47.0). Red River Chert shows a similar pattern, with a peak at 30 to 35 cm (%=40.6) and lower levels of occurrence above that (%=21.2 to 27.7); note that the percentage does not rise again in the surface collection, as with SRC. Knife River Flint has the opposite pattern. It occurs in small amounts in the lower two excavation levels (%=3.0, 1.6), rises somewhat in the immediately sub-plowzone levels (%=14.7, 13.8), and is most abundant in the plowzone (%=20.8); the level in the surface collection falls substantially (%=1.5). This makes sense from the perspective that local raw materials (RRC, SRC) are most important until the availability of a high-quality exotic material (KRF) increases. Then the use of the local materials diminishes in proportion to the availability of the exotic. This also makes sense from the perspective of the proposed Middle Archaic and Late Archaic components; there is limited KRF availability in the Middle Archaic, but substantially increased availability in the Late Archaic.

In the surface collection we see a drop in KRF and an increase in SRC, so that the figures are comparable to those in the lowest strata. No such pattern is seen in the plowzone. This might initially seem strange, unless we consider that the surface collection sampled a much larger area than the plowzone. The landscape context on this beach ridge complex includes slopes and swales, with differential potential for erosion and deposition. Thus there was the possibility for parts of an early occupation to be buried, while other parts of the occupation

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[3] Note that the data from this site are shown by 5 cm excavation level (plus surface and plowzone), so the reader can better evaluate how patterning changes within these deposits. Materials recovered below 40 cm (lowest stratum, plus pit feature content) are excluded because of small sample size.

Table 4-14. Percentage of aggregated assemblages found in the UP-1 sector of the utility plane.

Region / Subregion	Paleoindian Assemblages	Aceramic Assemblages	Ceramic Assemblages	Village Assemblages
Minnesota	**90.0**	**64.9**	**38.1**	**66.1**
South Agassiz	**91.9**	**60.8**	**52.0**	**57.9**
Tamarack	92.0	60.1	52.7	--
Upper Red	81.0	60.4	51.8	51.3
Shetek	99.4	62.4	51.6	57.9
West Superior	**89.1**	**49.6***	**27.4***	**--**
Arrowhead	89.2	69.0	52.8	--
Quartz	99.9	24.3*	25.1*	--
Pipestone	**--**	**--**	**--**	**--**
Hollandale	**97.1**	**82.2**	**77.9**	**68.0**

* Indicates data with known sampling or identification problems. Dash indicates that no data are available.

remained on (or nearer) the surface. Differential burial combined with plowing could account for the figures we see for the surface collection, if that collection in fact samples an expansive Middle Archaic habitation, part of which was also sampled by excavation from a buried context. This kind of interpretation of site structure points out an interesting potential use of utility analysis, one that might be explored at other sites, or by re-examining the piece-plotted data for the surface collection.

In addition, note that for the most part there seems to be a fairly abrupt shift from one pattern to another in the buried deposits. This could be taken to suggest the presence of two distinct components in the buried materials, rather than a gradual transition built up by repeated use of the immediate landscape over an extended period of time – during which raw material use patterns gradually changed.

It may also be worth noting that quartz is missing in the lower levels, and present in small amounts (up to 3.0%) in the upper levels and surface collection. This could be taken to suggest the presence of a Woodland component, as could a greater diversity of raw materials in the surface collection (including a single flake of Prairie du Chien Chert, the only piece in the assemblage). Peterson does note the recovery of a Pelican Lake point from the surface, which he interprets as indicating the presence of a surficial Woodland component.

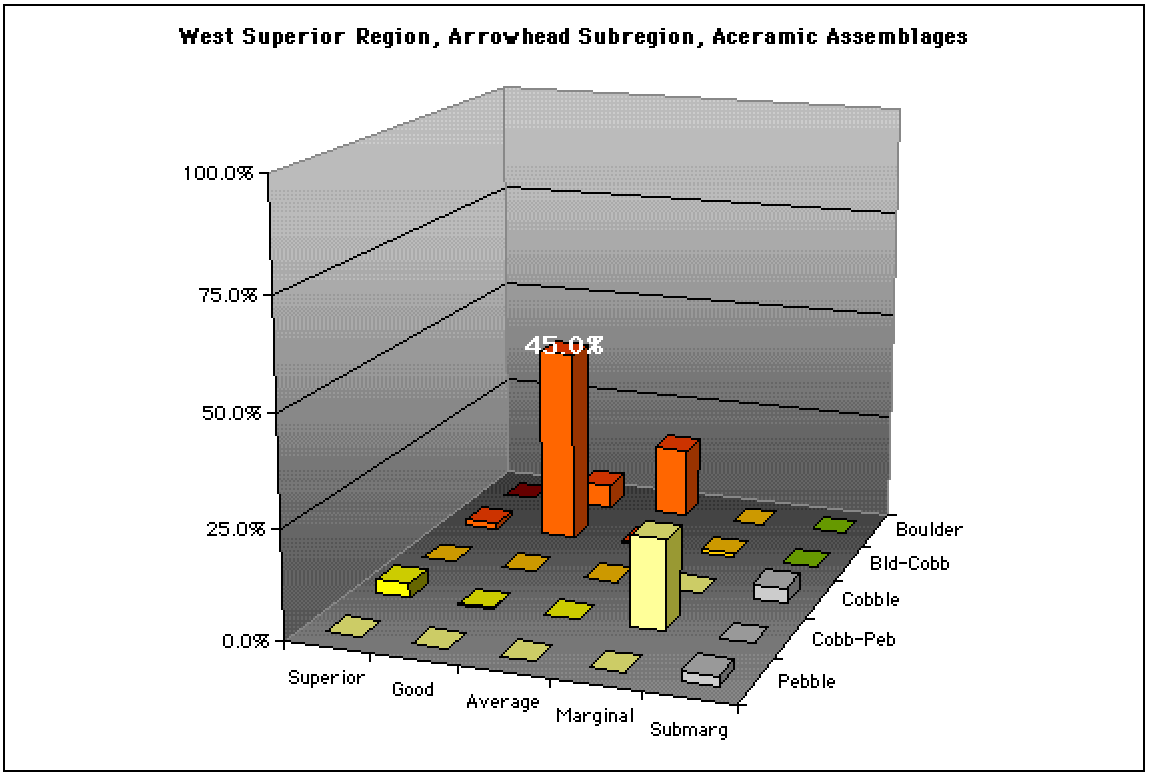
Finally we can note the presence of Border Lakes Greenstone Group materials throughout the column. They range from 5.0 percent in the lowest level, to between 12.0 and 13.8 percent in the middle levels, before decreasing to 7.9 percent in the plowzone and 8.3 percent in the surface collection. This is an interesting trend, but one that is hard to interpret. It might be seen as indicating variable connections to the north, except that Lake of the Woods Siltstone and Lake of the Woods Rhyolite are both potentially locally available.

Work at 21MA63 included surface collection and the excavation of a single 1 x 1 m excavation unit to a depth of 75 cm. A Brainerd Horizontally Corded rim sherd was found on the surface, and a few other sherds were recovered by excavation to a maximum depth of 45 cm. The excavation also encountered a flintknapping feature consisting of a concentration of Lake of the Woods Rhyolite. Artifact counts peak at 40 to 45 cm (n=53) and again at 60 to 65 cm (n=24), suggesting the presence of two distinct components. Peterson (1998:18) notes, of course, the presence of a Brainerd component (which we will call Early Woodland), and of "stratigraphically separate earlier deposits that probably date to the Archaic period." It is not clear whether he believes that the Brainerd component occurs at the surface and in the upper excavation levels, or whether Brainerd occurs on the surface and in the plowzone, and that the subplowzone artifacts represent one or more Archaic components.

The distributions of raw materials potentially supports this interpretation (Appendix 2: 21MA63). The percentage of Red River Chert is highest at 65 to 70 cm (%=64.3). The percentage drops until RRC is minor to absent from 35 to 50 cm, before it rebounds in the 30 to 35 cm level (%-10.0) and plowzone (%=9.5). Swan River Chert displays a very similar pattern, although the percentages are generally lower than for RRC. This stratigraphic distribution is similar to what we saw at 21MA62. In this case, however, KRF does not have a complementary distribution. Rather, KRF is most abundant in the two excavation levels from 60 to 70 cm (%=7.1, 4.2), it is minor to absent in the levels above that, and its presence strengthens again in the plowzone (%=4.8). In this case the distributions of SRC, RRC and KRF are more or less parallel.

In this case it is Lake of the Woods Rhyolite that displays a complementary distribution. In the levels between 30 and 55 cm, this rhyolite constitutes 75.0 to 100.0 percent of the lithic sample. This, of course, reflects the excavation of the flintknapping feature. Given the recovery of a few ceramic sherds throughout these same levels, it seems reasonable to associate the feature with the Brainerd component at the site. It would not be wise, however,

Figure 4-26. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the Arrowhead Subregion, West Superior Resource Region.



to associate Brainerd with a preferential use of Lake of the Woods Rhyolite – at least not based on this evidence. This is the case where the sample should not be considered representative of the broader raw material use pattern associated with Brainerd. This is not only because the excavation unit encountered the flintknapping feature, but because the sample came from a single excavation unit. Had it been possible to excavate a broader area of the site, we could have gotten a more representative view of Brainerd raw material use here. As the matter stands, however, we can only say that the Brainerd flintknappers apparently had no objection to working with Lake of the Woods Rhyolite.

It is interesting to note that in the lower levels RRC is more abundant than SRC. This is the opposite of the usual pattern. Red River Chert is usually available in smaller pieces than Swan River Chert, and it is tempting to see its relative abundance as suggesting bipolar reduction of pebble cores. This interpretation, however, would be better based on a re-examination of the artifacts from the site, with an eye towards documenting the presence of bipolar cores or other bipolar flaking debris. The matter of this mode of reduction is considered in greater depth in the review of ceramic and Woodland data below.

21BK111

21BK111 is a multicomponent site located on a glacial ridge on the north shore of Mission Lake in Becker County, in northwestern Minnesota. The site falls in the Upper Red Subregion of the South Agassiz Resource Region. Field work was conducted at the site in 2005, in anticipation of Tribal development on the land. The fieldwork documented a historic component associated with a mission school operated at that location from the late nineteenth to mid-twentieth centuries, and a prehistoric component believed to date to the Middle Prairie Archaic, or about 4500 to 5500 BP. This age is based on the recovery of two Oxbow projectile points and an Oxbow preform. The site is interpreted as a small, short-term habitation (Florin 2006).

Note that provisioning in the UP-1 sector totals 44.4 percent, considerably lower than regional Paleoindian assemblages or even a regional Early Archaic site like Rustad (Appendix 2: 21BK111). Provisioning in the UP-2 sector totals 31.4 percent, all of it accounted for by the use of Tongue River Silica. Most of the rest of the assemblage falls into the unidentified or generically identified category (%=18.1). Quartz is used, but at a low level of intensity (%=3.9). Red River Chert is relatively unimportant (%=1.5). A single flake of Prairie du Chien Chert indicates some connection to the southeast, and five pieces of Knife River Flint (%=1.5) indicate connection to the west.

It is interesting to compare this to the data from the Polk County flood-control survey sites (Table 4-19). First we can note the low intensity of KRF use in general, and in comparison to the roughly contemporaneous assemblage from 21PL27 or the earlier assemblage from Rustad. This is probably geographic variation and falloff in intensity of KRF use with increased distance from the source. Although this site is only about 50 miles (80 km) east of the Red River, the prevalence of KRF seems to fall off quickly east of the Red River (or possibly east of the Agassiz beach ridges that fall between the Red River and this site). The complement of this is the more intensive use of local raw materials, in this case Tongue River Silica in particular. The site is located in an area of Des Moines lobe till (Florin 2006), which would contain TRS in this subregion, and near Wadena Lobe till, which should contain more TRS is larger pieces (as discussed in Chapter 3). Note that the opposite

Table 4-15. Summary of lithic raw material composition for the Early Paleoindian projectile point inventory compiled by Higginbottom (1996), and Higginbottom and Shane (1996), not including four points that were not available for raw material identification, and with the addition of points from subsequent reports (Anfinson 2007; Bakken 2002b).

	n	**%**
South Agassiz Materials		
Red River Chert	--	
Silicified Wood	--	
Swan River Chert	--	
West Superior Materials		
Animikie Group	--	
- Biwabik Silica	--	
- Gunflint Silica	3	10.0
- Jasper Taconite	--	
- Kakabeka Chert	--	
Fat Rock Quartz	--	
Hudson Bay Lowland Chert	--	
Lake Superior Agate	--	
Pipestone Materials	--	
Hollandale Materials		
Cedar Valley Chert *	8	26.7
Galena Chert	--	
Grand Meadow Chert	1	3.3
Prairie du Chien Chert	--	
Tongue River Silica	**--**	
Border Lakes Greenstone Group		
Knife Lake Siltstone	1	3.3
Lake of the Woods Siltstone	--	
Lake of the Woods Rhyolite	--	
Sioux Quartzite Group	--	
Western River Gravels Group	--	
Quartz *(not specified)*	--	
Other *(cf. chopping tool matls)*	--	
Generic Identifications		

Table 4-15. Summary of lithic raw material composition for the Early Paleoindian projectile point inventory compiled by Higginbottom (1996), and Higginbottom and Shane (1996), not including four points that were not available for raw material identification, and with the addition of points from subsequent reports (Anfinson 2007; Bakken 2002b).

	n	%
Jasper	--	
Quartzite	--	
Unidentified	4	13.3
Exotic Materials		
Burlington Chert	2	6.7
Hixton Group	8	26.7
Knife River Flint	1	3.3
Obsidian	--	
Other Nonlocal Materials		
Fusilinid Group (Winterset Chert)	1	3.3
Maynes Creek Chert	1	3.3
TOTAL	**30**	**99.9**

* This is a minimum number. Anfinson (2007) notes "several" fluted points, and information from Koenen (personal communication 2011) indicates a minimum of three (some reworked into other tool types).

is true for the Polk County sites; TRS is not naturally present in the Tamarack Subregion, which helps to explain its scarcity at those sites.

It is also interesting to note the presence of four bipolar flakes (SRC=2, RRC=1, unidentified=1) and one bipolar core (RRC=1) in the assemblage. Bipolar reduction is present, but it seems to be a small element of the reduction activity of the site. This is a useful point to keep in mind when we later examine evidence from ceramic and Woodland assemblages, where bipolar reduction seems to be more important.

21YM50, Mazomani/Kvistero Homesite

The Mazomani/Kvistero Homesite is located on the edge of the Minnesota River trench, at the point where the Yellow Medicine River enters the trench. The site is in Yellow Medicine County, southwestern Minnesota. This falls in the Shetek Subregion of the South Agassiz

Resource Region. The site was investigated from 1992 to 1995 in connection with planned development in the Upper Sioux Agency State Park (Gonsior et al. 1996). Multiple short-duration components of widely varying ages were identified in a variety of landscape contexts. The data discussed here come from three strata in Subarea B; the first was at and near the surface, the second buried in a B-horizon, and the third associated with a buried A-horizon. Note that the investigators suggested the rock-covered bottom of the Yellow Medicine River as a likely source for local raw materials at this site.

Mazomani/Kvistero is an example of a multicomponent site where the ages of the three components are not clearly established, and where we might try to estimate their approximate ages by looking a raw material composition. The best point of reference for the age of any of these components is a possible Little Sioux point recovered from the middle component, which points to a Middle Archaic age. This site also has potential to help us reconstruct a history of the circulation of Prairie du Chien Chert.

In terms of raw materials, we can note the following data and trends (Appendix 2: 21YM50). Tongue River Silica is present in limited amounts in the lowest component (%=8.89), but moderately important in the middle (%=19.4) and upper (%=22.5) components. Quartz is not very well represented in any of the components, but is more abundant in the lower component (%=6.9) than in the middle (%=2.0) and upper (%=1.1) components. The levels of unidentified or generically identified materials are rather high in all three components, with the lower component at 10.8 percent, the middle at 19.4, and the upper at 14.9. Swan River Chert occurs in roughly the same levels through all three components (lower=18.6%, middle=22.9%, upper=17.2%), while Red River Chert is minor in the lower component, but moderately important in the upper two components (lower=3.9%, middle=15.9, upper=17.2).

The figures for Prairie du Chien Chert are especially interesting. The lower component has a high percentage (%=30.4), with a decrease in the middle component (%=5.5) and a further decrease in the upper component (%=1.1). Further note that PdC is the only Hollandale material present in the lower component, while Grand Meadow Chert is also present in the middle component (%=4.5) and Cedar Valley Chert in the upper (%=3.4). Small amounts of Burlington are present in all three (no more than 2 percent), while Knife River Flint occurs at similar levels in all three components (lower=5.9, middle=3.5, upper=6.9). In addition, there are two flakes of Fusilinid Group chert in the middle component (%=1.0) Other materials occur in relatively small and stable percentages.

The investigators note that bipolar technology is present in all three of the components, although it is more strongly represented in the upper component. They note that

> The lack of naturally occurring high quality silicates in cobbles of usable size resulted in the use of small rounded cobbles. Many of these small cobbles were tested and/or initially reduced on anvil stones (bipolar reduction) resulting in bipolar debris even though the intent and final product was bifacial. [Gonsior et al. 1996:6-17]

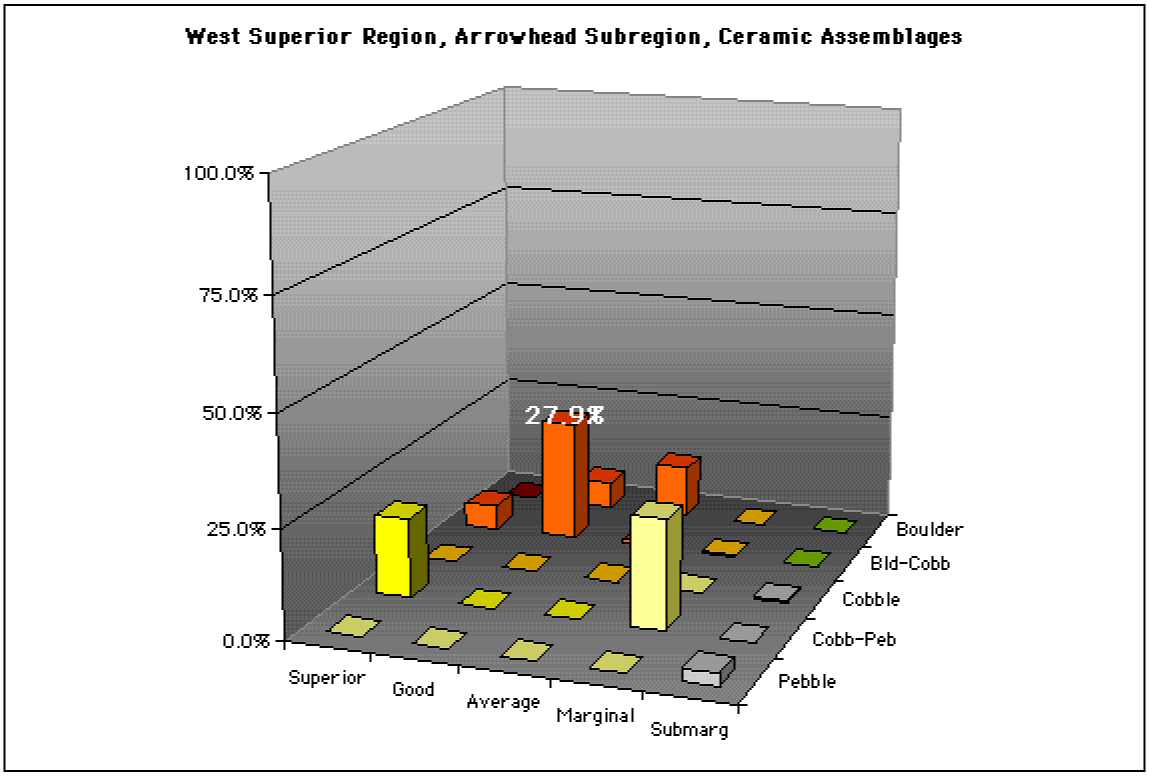
The XYZ depictions present a rather interesting perspective on the data from these three components. For the lower component, 62.7 percent of provisioning is concentrated in the UP-1 sector. For the middle component this figure drops to 36.9 percent, and it equals 42.8 in the upper component. The main change that accounts for this is the marked increase in the use of both Red River Chert and Tongue River Silica in the middle and upper components. The complement of this is the decrease in the importance of PdC from the lower component to the middle and upper components.

The authors suggest that the lower component might be Late Paleoindian, or possibly Early Archaic. In addition, since the evidence suggests a possible Middle Archaic age for the middle component, the age of the lower component is restricted to the range of Paleoindian to Middle Archaic. The XYZ analysis does not show a typical Paleoindian distribution of provisioning for this component. Too much provisioning is distributed outside of the UP-1 section, with smaller and poorer-quality raw materials. This should argue against a Paleoindian attribution for the lower component, which would restrict its age to Early to Middle Archaic. The XYZ distribution would probably not preclude this, but the presence of a high percentage of PdC could indicate against an Early Archaic age if the hypothesis about an Early Archaic collapse of raw material circulation is correct.

Further, there appears to be a clear change in the raw material provisioning pattern between the lower component on one hand, and the middle and upper components on the other. The latter two resemble each other to a strong degree. If we posit that the latter two components represent a "typical" Archaic profile for this area, it leaves us to wonder whether the lower component does represent regional raw material use for the Early Archaic. That also leaves us to wonder about the history of circulation for Prairie du Chien Chert, and whether the hypothesized collapse of raw material circulation exists, or whether it might be associated only with particular regions or raw materials.

In this case, we might conclude that the XYZ analysis helped us to gain a different perspective on raw material use between the three components, and helped us to discuss it in a potentially productive way. What the analysis has not done in this case, however, is to

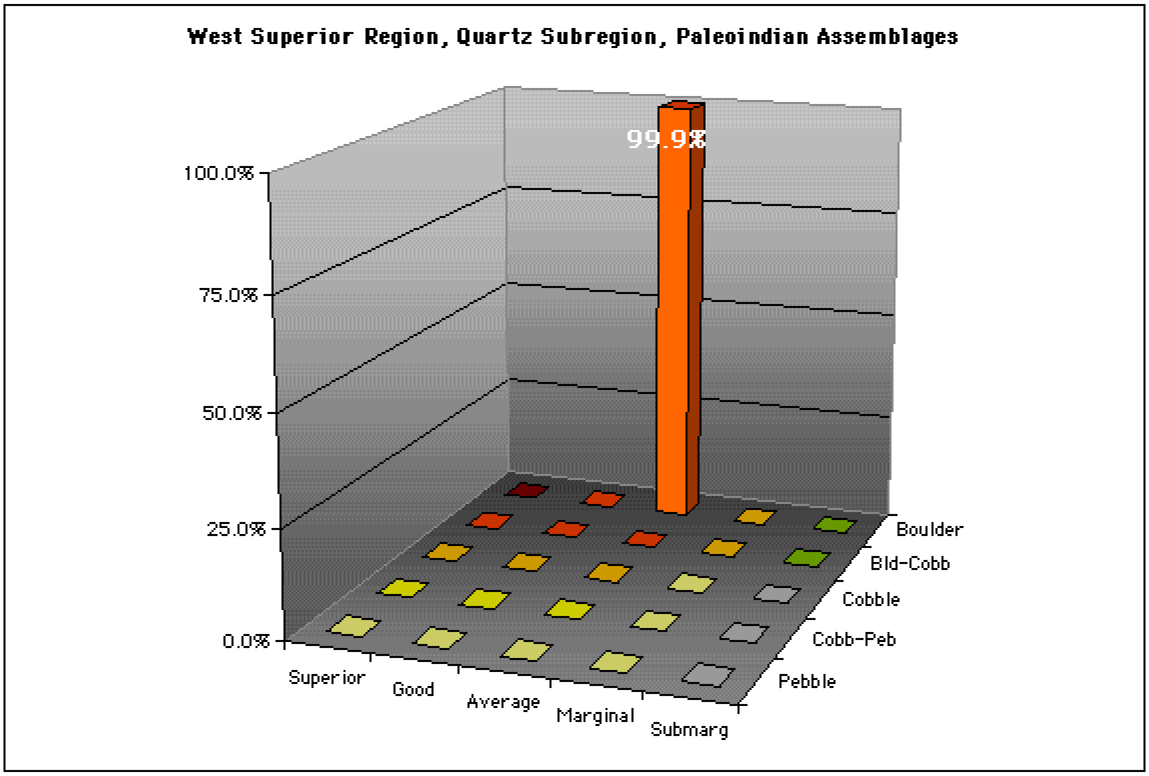
Figure 4-27. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the Arrowhead Subregion, West Superior Resource Region.



really come any closer to pinning down the ages of the components. There is a chance this reflects some kind of sampling problem, whether associated with the excavation or with a brief-duration use of the site that left an atypical assemblage (in the lower component). I suspect, however, that it may well have to do with a scarcity of general comparative regional information and with a similar scarcity of information on changes in the circulation of PdC through time. In that case, if we were to revisit the analysis after looking at a suitable set of other assemblages, 21YM50 might well yield to this kind of analysis.

It should be noted that the authors also undertook a correspondence analysis to test the affiliation of each component with raw material source regions (Gonsior et al. 1996:6-19, 7-4). Given that local resources predominated in all components, the results suggested that the lowest component was most strongly associated with the Hollandale Resource Region, the

Figure 4-28. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the Quartz Subregion, West Superior Resource Region.



middle component with the South Agassiz Resource Region, and the upper component with western sources (i.e., Knife River Flint).[4]

21CA198, East Lydick Creek, Area C East

The East Lydick Creek site is located on Lydick Creek near its confluence with the Mississippi River in north-central Minnesota. This falls in the Quartz Subregion of the West Superior Resource Region. The site was investigated in stages from 1989 to 1994 (Emerson 1996). The investigations identified distinct artifact concentrations and multiple components, ranging from aceramic (and presumably Archaic) to Woodland in age. The

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4. This report represents an early application of the original regional resource model (Bakken 1995a, 1997). It is interesting to note that the investigators find utility in the model, but already propose revisions to the boundary between the "western" (South Agassiz) and "southern" (Hollandale) regions (Gonsior et al. 1996:6-8 to 6-10).

following discussion pertains to the part of the site called Area C East, since this is where a lower aceramic component is most clearly expressed. Note that the upper component in this area only produced a very small sample of ceramic sherds, but it was interpreted as a part of a broader ceramic component seen in other portions of the site. The ceramics from Area C were comparable to the Bird Lake type (see Lenius and Olynik 1990), which would suggest a date in the range of about A.D. 1000 to 1650.

For the purposes of this discussion, the stratigraphic column for Area C East is divided into four parts, based on similarities in raw material composition between the various layers, and on peaks in artifact density at 30 to 35 cm (upper component) and 75-80 cm (lower component). This follows Emerson's definition of two components, but distinguishes strata where the components appear to commingle. The surface to 15 cm sample resembles the 30 to 35 cm peak, but with more HBLC and quartz. The 15 to 55 cm sample represents the heart of the upper component. The 55 to 70 cm sample exhibits characteristics of both the upper and lower components, and is interpreted here as a mix of the two. The 70 to 100 cm sample represents the heart of the lower component.

Note in particular the contrast between the main samples of the upper (15-55 cm) and lower (70-100 cm). At first glance, the lower component looks something like the profiles seen with Paleoindian assemblages (Appendix 2: 21CA198). Provisioning in the UP-1 sector actually only amounts to 14.6 percent, however, and most provisioning falls instead into the UP-2 part of the utility plain (%=83.9), which represents smaller or lower quality raw material stock. The tall column to the right in fact represents an abundance of Tongue River Silica (%=83.9). Recall that TRS is avoided generally in Paleoindian assemblages in Minnesota (although it was common in the Paleoindian component at the Cherokee site in Iowa). The shorter column with the UP-1 sector represents Swan River Chert. Note that very little else occurs in this assemblage beyond TRS and SRC. KRF is present at a very low frequency (n=1, %=0.3), but on the whole this represents intensely local raw material use. That represents a condition we have seen with some Early Archaic assemblages, although on the whole the patterning seen here is not immediately familiar. The suggestion has been made, however, that such a high-TRS pattern is in fact characteristic of Archaic assemblages from the Headwaters region where the East Lydick Creek site is located. Hohman-Caine and Goltz (1995b) discuss this at some length, and illustrate their discussion with lithic data from numerous Headwaters assemblages; their discussion is reviewed in greater detail below (under "Observations by Other Researchers").

Table 4-16. Summary of lithic raw material composition for the Late Paleoindian projectile point inventory compiled by Florin (1996), not including 144 points that were not available for raw material identification.

	n	%
South Agassiz Materials		
Red River Chert	3	1.2
Silicified Wood	--	--
Swan River Chert	10	4.0
West Superior Materials		
Animikie Group	1	0.4
- Biwabik Silica	--	--
- Gunflint Silica	4	1.6
- Jasper Taconite	11	4.4
- Kakabeka Chert	--	--
Fat Rock Quartz	--	--
Hudson Bay Lowland Chert		
Lake Superior Agate	1	0.4
Pipestone Materials	**--**	**--**
Hollandale Materials		
Cedar Valley Chert	5	2.0
Galena Chert	7	2.8
Grand Meadow Chert	1	0.4
Prairie du Chien Chert	38	15.2
Tongue River Silica	1	0.4
Border Lakes Greenstone Group		
Knife Lake Siltstone	49	19.6
Lake of the Woods Siltstone	--	--
Lake of the Woods Rhyolite	7	2.8
Sioux Quartzite Group	--	--
Western River Gravels Group	--	--
Quartz *(not specified)*	--	--
Other *(cf. chopping tool matls)*		
Basalt *	1	0.4
Generic Identifications		
Jasper	3	1.2

Table 4-16. Summary of lithic raw material composition for the Late Paleoindian projectile point inventory compiled by Florin (1996), not including 144 points that were not available for raw material identification.

	n	%
Quartzite	2	0.8
Unidentified	39	15.6
Exotic Materials		
Burlington Chert	2	0.8
Hixton Group	39	15.6
Knife River Flint	21	8.4
Obsidian	--	--
Other Nonlocal Materials		
Cobden Chert	3	1.2
Moline Chert	1	0.4
Wassonville Chert	1	0.4
TOTAL	**250**	**100.0**

* This raw material identification seems unlikely, but is reproduced here as reported.

The upper component lacks the tight provisioning focus of the lower component. Provisioning with the UP-1 sector totals 45.0 percent, while in this case no provisioning falls within the UP-2 sector. Instead the remainder of provisioning (%=40.4) falls outside these two sectors. The patterning of this upper component looks fairly familiar when it is compared to other ceramic-period assemblages. This type of distribution is discussed below, in the review of ceramic and Woodland data, where the ceramic data from East Lydick Creek is also examined in greater detail.

Note the display of the data from the levels between the upper and lower components (55-70 cm). This can be fairly simply explained as a mixture of the two components, one that favors the lower component but clearly includes characteristics of the upper component. There is no need to invoke the presence of an additional component. I would also propose that it is easier to explain this as a mixture of the two components, most likely through the agency of bioturbation, then to explain it as a gradual shift from one pattern to another. We might (or might not) see such a shift at another site with different conditions, but not here.

Observations by Other Researchers

In terms of both changes between Paleoindian and Archaic raw material use patterns, and changes in use patterns during the Archaic, Syms offers a set of useful observations for southern Manitoba. These pertain specifically to projectile point data. (It is worth noting again that while projectile point data can be very informative, it is not directly comparable to data for full lithic assemblages.) Syms (1977:31) observes that

> Furthermore, it is evident that different archaeological complexes through time reflect changing preferences for certain materials. Little systematic effort has been made to identify and quantify raw materials from Manitoba sites, yet certain trends are apparent. Projectiles from southern Manitoba demonstrate a preference for Knife River flint during the Paleo-Indian Period, Swan River chert for Archaic forms such as McKean, a return to Knife River flint during the late Archaic, an overwhelming preference for Knife River flint for Sonota projectiles, and a fairly high percentage of late side-notched projectiles of Knife River flint (Syms 1969; Leonoff 1970; Richards 1974).

Two particularly interesting points here are the importance of Swan River Chert in the Middle Archaic McKean complex, and the "return" to Knife River Flint in the Late Archaic. Note that SRC is found in southern Manitoba, while KRF is not. Both of these reinforce the scenario of a reduction in circulation of raw materials (or at least some raw materials, including KRF) in the earlier part of the Archaic, and an increase of KRF use in the Late Archaic.

Picha and Gregg (1987:201) add an interesting observation here in terms of the circulation of Knife River Flint:

> Results of investigations in the [KRF] quarry area indicate specifically that intensive use occurred during the period ca. 3200-1500 B.P. (Root et al. 1986:436-440). This temporal span of 1700 years encompasses a portion of the Late Plains Archaic period, all of the Early Plains Woodland period, and a portion of the Middle Plains Woodland period in the study area.

There is general agreement between this chronology derived from the quarries, the data reviewed above, and the information provided by Syms. It is also interesting to compare the quarry-based chronology with the information from Polk County shown in Table 4-19. Note that the highest percentages in that table do in fact coincide rather nicely with the period of 3200 to 1500 BP mentioned by Picha and Gregg. It seems that, based on such multiple sets of evidence, an outline of the history of Knife River Flint use and circulation is within reach.

Hohman-Caine and Goltz (1995b) present a valuable discussion of the Archaic for the

Mississippi River Headwaters area of north-central Minnesota. They provide a thorough review of background to the topic, present data from relevant Headwaters sites, and consider the significance of the information from a broad perspective. As part of their analysis and synthesis, they discuss patterns of raw material use for the Headwaters area. Their work on the latter topic has been especially helpful in informing my own research on the topic. Their sample included 15 sites, 1 of these Paleoindian, 4 predominantly Archaic, 1 possibly Archaic and Brainerd (Early Woodland), 4 Brainerd, 4 Late Woodland, and 1 unknown.

They first note that "Patterning of raw materials between sites is quite evident," (Hohman-caine and Goltz 1995b:44) and then go on to make a number of specific observations about this patterning. For the Paleoindian component they note the predominance of Animikie Group silicates, especially Jasper Taconite. The percentage is not given, but their Figure 2 suggests it is on the order of 90 percent. They also note "low frequencies or absence of raw material types which have unsuitable characteristics (QTZ [quartz], TRS) or occur in nodules too small for making large tools (CHT [undifferentiated chert], SRC)" (Hohman-Caine and Goltz 1995b:45). These observations concur nicely with the data and observations presented above (Paleoindian Data). In addition, they note that these Animikie Group materials are minor or absent in other, later assemblages.

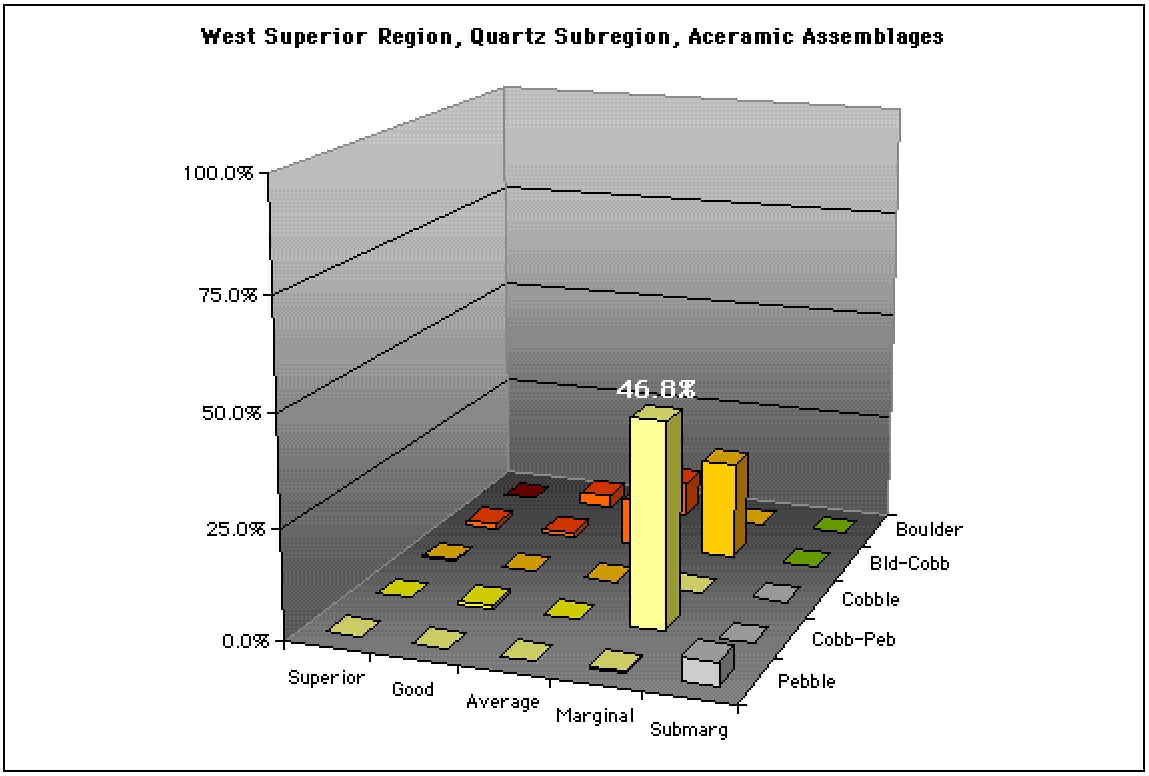
For the Archaic they note that Swan River Chert is present and can dominate the assemblage. Tongue River Silica is abundant. Knife River Flint, in contrast, is "virtually absent" (Hohman-Caine and Goltz 1995b:45).

For the Brainerd (Early Woodland) assemblages, "the most notable characteristics are low to absent Tongue River Silicified Sediment (TRS), low Knife River Flint (KRF), and moderate frequencies of Quartz (QTZ) and Swan River Chert (SRC)" (Hohman-Caine and Goltz 1995b:46).

In the Woodland assemblages, Swan River Chert is present and can dominate the assemblage. The amount of KRF is variable; it is absent or nearly so in two of the assemblages, and abundant in the other two. They further note the absence of TRS in these assemblages, although their Figure 2 seems to indicate minor amounts of TRS.

Excavation of the North Sugar Lake site produced abundant remains associated with Blackduck ceramics, and a single Pelican Lake point that hinted at the presence of an earlier, Archaic component (Hohman-Caine and Goltz 1995b:39, 45-46). For this reason, the lithic data was analyzed by depth (0-10, 10-15, 15-20 cm below surface). The results are quite interesting, and strongly suggest that the Archaic component is present. They also help to organize and highlight some of the trends summarized in the preceding paragraphs. TRS goes

Figure 4-29. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the Quartz Subregion, West Superior Resource Region.



from being the predominant material in the lower stratum to almost absent in the upper stratum. SRC appears to decrease slightly in importance. Quartz generally increases, although the highest intensity of use comes in the middle stratum. It is especially interesting to note that KRF goes from a minor element in the lower stratum to being the predominant raw material in the upper stratum. According to the theory that increased availability of a superior material like KRF should lead to greatly diminished use of a marginal-quality material like TRS, it is not surprising to see a great decrease in the use of TRS. What is harder to reconcile, however, is the general increase in quartz use along with the rising percentages of KRF.

The researchers also ran into the kind of problem we have discussed above in some cases. At the Cass Lake Campground site, the only diagnostic artifacts were Brainerd ceramics, yet the raw material profile look more like the Archaic sites than the Brainerd sites. They note that because of disturbance to the site, looking at raw material profiles by depth does not help to resolve whether there might be two components present (as at North Sugar Lake).

In addition to the general lithic data, Hohman-Caine and Goltz (1995b:47-48) present a projectile point inventory for the Horseshoe Bay site, based on 56 points (Paleoindian=4, Archaic=27, Woodland=12, probably Woodland=3):

> The Paleoindian points show a higher percentage of Knife Lake Siltstone (KLS). Hixton Silicified Sandstone (HSS) and Knife River Flint (KRF), Hudson Bay Lowland Chert (CHT), Swan River Chert (SRC), Quartzite (OTH) and Biwabic Chert (GFF) were each represented by a single projectile point.... Quartz (QTZ) and Tongue River Silicified Sediment (TRS) were absent.
>
> Archaic points were dominated by Swan River Chert (SRC) with moderate amounts of Tongue River Silicified Sediment (TRS), Chert (CHT), and Knife Lake Siltstone (KLS). Gunflint Formation (GFF), Quartz (QTZ), and Quartzite (OTH) are represented by a single projectile point each. Knife River Flint (KRF) is absent.
>
> The Woodland points are dominated by Swan River Chert (SRC), with high percentages of Knife River Flint (KRF). Chert (CHT) and Quartz (QTZ) have moderate frequencies while Gunflint Formation (GFF), Knife Lake Siltstone (KLS), and Tongue River Silicified Sediment (TRS) are each represented by a single projectile point.... [Hohman-Caine and Goltz 1995b:47]

In this analysis, we see confirmation of distinguishable difference of patterns of raw material use between Paleoindian, Archaic, and Woodland assemblages. The trends generally match those we have reviewed so far. Unfortunately we cannot examine their information from the XYZ perspective, since the report does not provide exact counts or percentages, although it seems that we would generally see a progression from provisioning in the UP-1 sector, to the UP-2 sector, and then further reconfigurations with the Woodland data. It is particularly interesting to note that an Early Woodland Brainerd pattern seems to be distinguishable from a Late Woodland pattern, since it has been difficult to address this level of distinction in my own research. The matter clearly merits further research.

While Hohman-Caine and Goltz's discussion has a great deal in common with the research presented in this thesis, their conclusions are framed somewhat differently than mine, and one aspect of that deserves particular mention. In some respects it is reminiscent of the correspondence analysis results presented by Gonsior et al. (1996) for the Mazomani/Kvistero Homesite (above). Hohman-Caine and Goltz (1995b:48) make the following observations in conclusion (emphasis added):

> While all cultural traditions are dominated by the use of local materials, striking differences exist through time. During the Paleoindian, there is a high use of both western and eastern exotic raw materials.
>
> During the Archaic, *all raw materials used could have been locally derived*. During the Woodland, there is a substantial use of western raw materials.

> A number of preliminary hypotheses can be derived from this patterning. During the Paleo, territories were substantially larger than during the subsequent Archaic and Woodland, which encompassed important quarry sites of high-quality materials. High quality materials, generally absent in the Headwaters, were required by the technological limitations of the preferred projectile point styles: large points, frequently fluted and thinned by driving long percussion flakes across the surface, required large blanks of high quality.
>
> The regional specialization which began to develop in the Archaic may have resulted in a *breakdown of trade networks or the size of travel spheres*. There was more competition for resources, and increased use of local materials which were suitable for smaller points.
>
> During the Woodland, there was increased trade/travel with the Plains, as the Woodland-Prairie border shifted west. This is reflected in the increased use of exotic materials from the west, even though local materials may have been suitable for small projectile points.

Their use of the phrase "breakdown of trade networks" is particularly striking, given some of the previous discussion in this thesis (e.g., the Cherokee site). To their observation I would only add a restatement of my hypothesis that such a breakdown may be more a characteristics of the Early Archaic than the Archaic as a whole. It might be particularly interesting to test this hypothesis in the Headwaters region and north-central Minnesota in general, since exotic and other nonlocal raw materials generally constitute a small percentage of lithic assemblages. We might investigate whether relatively small percentages (or changes in percentage) are diagnostic of chronological position within the Archaic. Alternatively, we might also examine whether different nonlocal materials (potentially originating from different directions) might serve a similar function.

It may be helpful to briefly recapitulate some of the observations from other researcher presented above, pertaining to the West Superior Resource Region and in particular the Arrowhead Subregion. Mulholland and Shafer (2000:52-53) note that in post-Paleoindian assemblages, the percentage of Knife Lake Siltstone decreases. Mulholland (2002), Mulholland and Shafer (2000), and Kuehn (1998) all note that Hixton Quartzite seems to be preferentially associated with Paleoindian assemblages, is present in Archaic assemblages, but occurs only sporadically in Woodland contexts.

Hamilton (1996) and Halverson (1992) make similar observations about the use of Jasper Taconite (and other Animikie Group materials) for the part of the Arrowhead Subregion that lies in Ontario. Hamilton (1996:73, citing a personal communication from Bill Ross) also notes that "later groups (late Archaic and Woodland) made more frequent use of fine cherts, quartz and quartzite derived from tills and stream sorted gravel deposits." Hinshelwood (1994:48) notes that "The use of HBL appears to commence in the Archaic, and, although

Kakabeka chert is often used in late palaeoindian occupations, its use is relatively minor until the Archaic also."

Summary

In the Archaic and general aceramic data, we see provisioning expanding significantly beyond the UP-1 sector of the utility plane, and in particular into the UP-2 sector. This equates with the use of poorer quality materials like Tongue River Silica, previously ignored in most regions, and the use of pieces with smaller package size. The latter include materials like Red River Chert, Kakabeka Chert, Hudson Bay Lowland Chert, Grand Meadow Chert, and others. As a result, the focal materials in the Paleoindian assemblages, while generally still found in Archaic assemblages, become less important. The exception is Knife Lake Siltstone, which sees much lower levels of use in the Archaic. As discussed, the use of Fat Rock Quartz in (and after) the Archaic remains enigmatic. Since it seems to fit it in the UP-2 sector (cobble size stock, average flaking quality) we could expect its use to increase, but available data does not presently allow resolution of the question. In the Hollandale Resource Region, there is also evidence for the increased use of raw materials from glacial sediments, in addition to the materials from primary geological context. This is principally the case in parts of the region where glacial sediments are common, but apparently not in the areas where such sediments are rare.

This expansion of provisioning to the UP-2 sector means that these assemblages also have overall greater raw material diversity. The assemblages simply contain more kinds of toolstone than the typical Paleoindian assemblages. Even so, there are still many kinds of toolstone that we know are part of the natural resource base but which are not showing up in any significant amounts in the Archaic and general aceramic data. More specifically these are the raw materials that occur in yet smaller package size (cobble-pebble and pebble on the utility plane scale).

An interesting issue that arises with the aceramic and Archaic data is the balance of local versus nonlocal toolstone. At the beginning of the Archaic, we see what seems to be a general collapse in the circulation of raw materials (although there may be exceptions in some regions or for some raw materials). Sites like Cherokee and 32RI75 offer evidence that circulation of at least some raw materials is re-established by the Middle Archaic, and may even be substantial in some cases. Seeing whether this is a gradual process or one with clear thresholds will require examination of further data. By the later part of the Late Archaic,

Table 4-17. Adaptation of Halverson 1992:62, "Table 6: Intrasite Comparison of Debitage Percentages by Raw Material Type" for Paleoindian sites near Thunder Bay in northwestern Ontario.

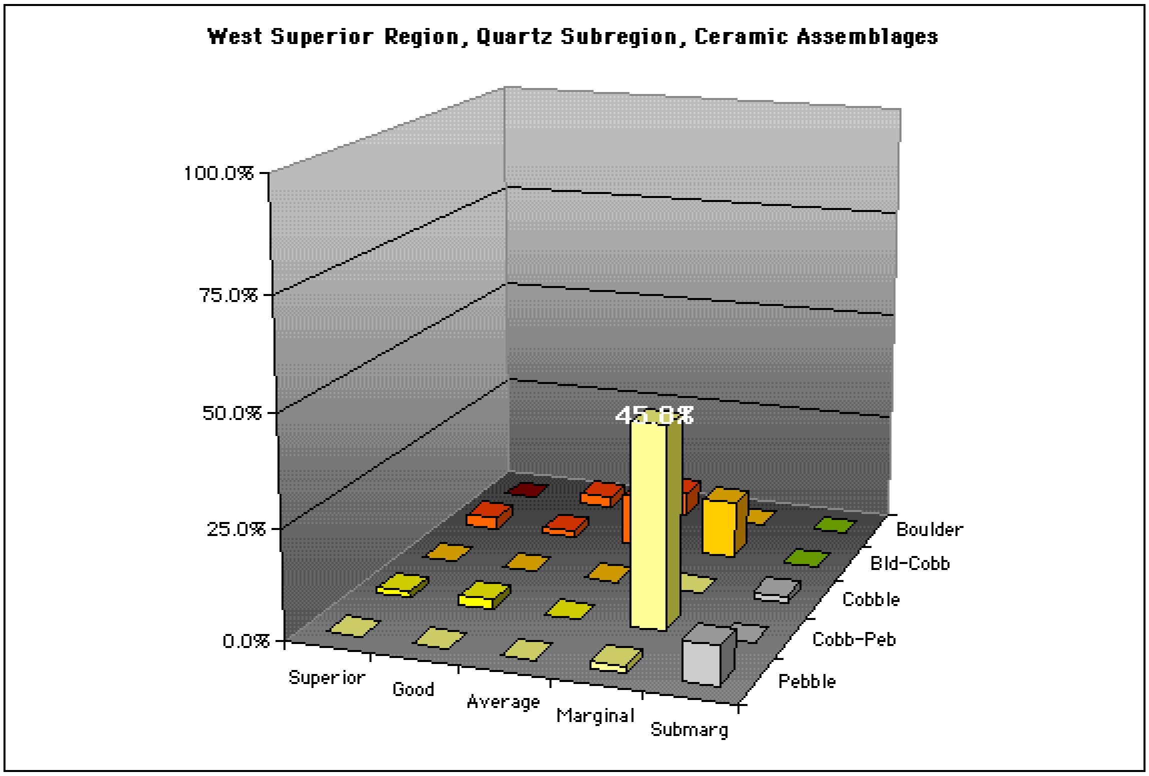
Site	**T**	**G**	**M**	**S**	**Q**	**HI**	**HBL**	**AG**	**SH**	**K**	**Q**	
Simmonds (DcJh-4)	90.2	9.3		0.3	0.1					0.05	0.05	100.0
Brohm (DdJe-1)	93.2	1.9	0.8	0.3	2.8	0.3	0.3	0.1			0.6	100.3
Cummins (DcJi-1)	100.0 *											100.0
Biloski (DcJh-9)	98.6								1.4			100.0
Widar (DcJi-8)	100.0											100.0
Hartstone Hill (DcJj-11)	76.3	1.3							1.3	18.8	2.5	100.2
River Terraces (DcJh-38)	95.6	4.4										100.2
Tower Road (DbJm-6)	99.2	0.2							0.6			100.0

T - Taconite; G = Other Gunflint Formation material; M = Mudstone; S = Siltstone; Q = Quartz; HI - Hixton Silicified Sandstone; HBL = Hudson Bay Lowland Chert; AG = Lake Superior Agate; SH = Shale; K = Kakabeka Chert; O = other

several of the sites we examined provide evidence that the circulation of raw materials, at least Knife River Flint, is clearly re-established. In the particular case of KRF, the circulation reaches what may be an all-time high in terms of overall extent and intensity. Again, we will need to examine additional evidence to see if this is a gradual buildup or one with clear thresholds. It should also be interesting to try to track circulation patterns for the other main exotics in the region, as well as for the movement of other nonlocal raw materials between resource regions.

We do have some information on core types associated with these assemblages. At least for the Bass site, the investigators described cores that – unlike the Paleoindian Beauty Lake cores – were not patterned, but instead were "unceremoniously bludgeoned wherever edge angles permitted easy flake extraction" (Stoltman et al. 1984:209). Evidence from

Figure 4-30. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the Quartz Subregion, West Superior Resource Region.



21BK111 also indicates that bipolar cores can appear in these assemblages, although they do not seem to be common.

The evidence reviewed so far appears to indicate two separate and distinguishable patterns of raw material provisioning and use. With this in mind we can proceed to examination of the general ceramic and Woodland data, to see how it compares to the evidence we have reviewed above.

Ceramic and Woodland Data

Aggregated Data

In the ceramic assemblages, the aggregated data show a continuation of the trend of broadening raw material procurement. In this case the change is less towards poorer quality raw materials than towards materials with smaller package size. More specifically, this appears to be the increased use of pebbles. In the XYZ diagrams (Figures 4-5, 4-9, 4-13, 4-16, 4-20, 4-24, 4-27, 4-30, 4-33) this mostly shows up as an increased percent of the assemblages falling in the UP-3 sector, and especially in the cobble-pebble size range. The percent falling in the pebble row also increases, also the increase is less obvious. The trend towards provisioning in the UP-3 utility sector is clearer in Table 4-21, which summarizes the total percentage by assemblage of the cobble-pebble and pebble size materials. The percentage clearly peaks in the ceramic assemblages, except in the case of the Quartz Subregion. This exception likely reflects the problem with quartz identification discussed above (Chapter 3).

A look at the underlying data (Tables 4-4, 4-7 to 4-12) indicates that this trend reflects two changes in terms of specific raw materials. First, some new materials come into use (or increase from very minor or sporadic use). These should be the materials that occur principally or almost exclusively as pebbles. In most or all parts of the state, this seems to include a variety of raw materials that are only generically identified. (It seems likely that, upon review, many of these materials might fit into one of the specifically identified minor categories.) In the South Agassiz Region, this includes quartz. In the Upper Red and Shetek Subregions, it also includes the Western River Gravels Group, local Knife River Flint and silicified wood. In the West Superior Region, this includes Lake Superior Agate and may include Hudson Bay Lowland Chert. It may also include quartz other than Fat Rock Quartz, although as noted this is not clear. In the Hollandale Region, this probably includes quartz.

Second, some raw materials that were previously used at a significant level become more important. This seems to be especially applicable with raw materials in the cobble-pebble size range. It seems reasonable to suggest that this involves use of larger pieces of a material in the aceramic assemblages, expanding to use of both larger pieces and pebbles of the material in the ceramic assemblages. In the South Agassiz Region, Red River Chert provides a good illustration. Some percentage of RRC clasts are cobble sized, and some of these pieces were used in both Paleoindian and especially aceramic assemblages. However, most RRC clasts are pebbles, and these apparently were more intensively used in ceramic assemblages. Thus the intensity of RRC use increases in steps from minor to important. This progression could clearly pertain to any raw material, but it is only obvious for some. Why it is obvious only for some is not clear, but conceivably might be resolved by more detailed raw material resource survey that focused on package size as well as general availability.

The aggregated ceramic data provides some evidence for increased circulation of exotic and other nonlocal raw materials, as well as the circulation of raw materials between adjacent resource regions. As with the aceramic assemblages, however, a closer look at the data indicates that the situation is more complex and interesting than such a preliminary statement would suggest. And again, the matter is better reviewed in the context of the multicomponent and selected assemblage data reviewed below.

DdKm-1, Long Sault Rapids

The Long Sault Rapids site is located along the Ontario side of the Rainy River. This falls along the border between the Tamarack Subregion, South Agassiz Resource Region to the west and the Arrowhead Subregion, West Superior Resource Region to the east. (Note, however, that this part of the regional boundary is especially arbitrary, and should not be accorded greater significance than it warrants.) The investigators were able to identify multiple components at the site, including Late Archaic (as late at 2500 BP), Middle (Initial) Woodland (possibly ca. AD 750), Late Woodland (part dating ca. AD 1000 to 1200, part dating ca. 1400 to 1600), and Historic (eighteenth or nineteenth centuries). Arthurs (1982, 1986) notes differences in raw material composition between the various components, and in fact discusses it at some length. The following observations parallel his to a great degree, although his provide more detail and his analytical emphasis is somewhat different.

The distribution of materials by utility plane sector for each component (Table 4-22; Appendix 2: DdKm-1) shows an interesting trend. Note first the strong resemblance between the Archaic and Middle Woodland assemblages in these terms. They are, in fact, practically identical. With the Late Woodland assemblage, however, the percentage of the assemblage in the UP-1 sector falls, and it falls again in the Historic assemblage. Correspondingly, of course, the percentage of materials in the UP-3 sector rises. (The lack of provisioning in the UP-2 sector points to the general local lack of local toolstone resources in that sector, at least as the raw materials are currently placed in the utility plane.) Note, in fact, the near-complete reversal of the importance of these sectors: UP-1 begins at 67.8, while UP-3 ends at 62.3.

In terms of specific raw materials, the changes in the UP-1 sector are related to changes in the prevalence of SRC and Border Lakes Greenstone Group materials (mostly Lake of the Woods Rhyolite). Swan River Chert is high in the Archaic component (%=29.2), falls in the Middle Woodland (%=12.4), holds steady in the Late Woodland (%=11.7), and finally rises somewhat in the Historic assemblage (%=16.8). Arthurs attributes this to changes in degree

Table 4-18. Adaptation of Hamilton's (1996:74) "Table 4 Lithic raw material selection from a range of sites" for Paleoindian and selected other sites near Thunder Bay in northwestern Ontario, including the most common raw materials.

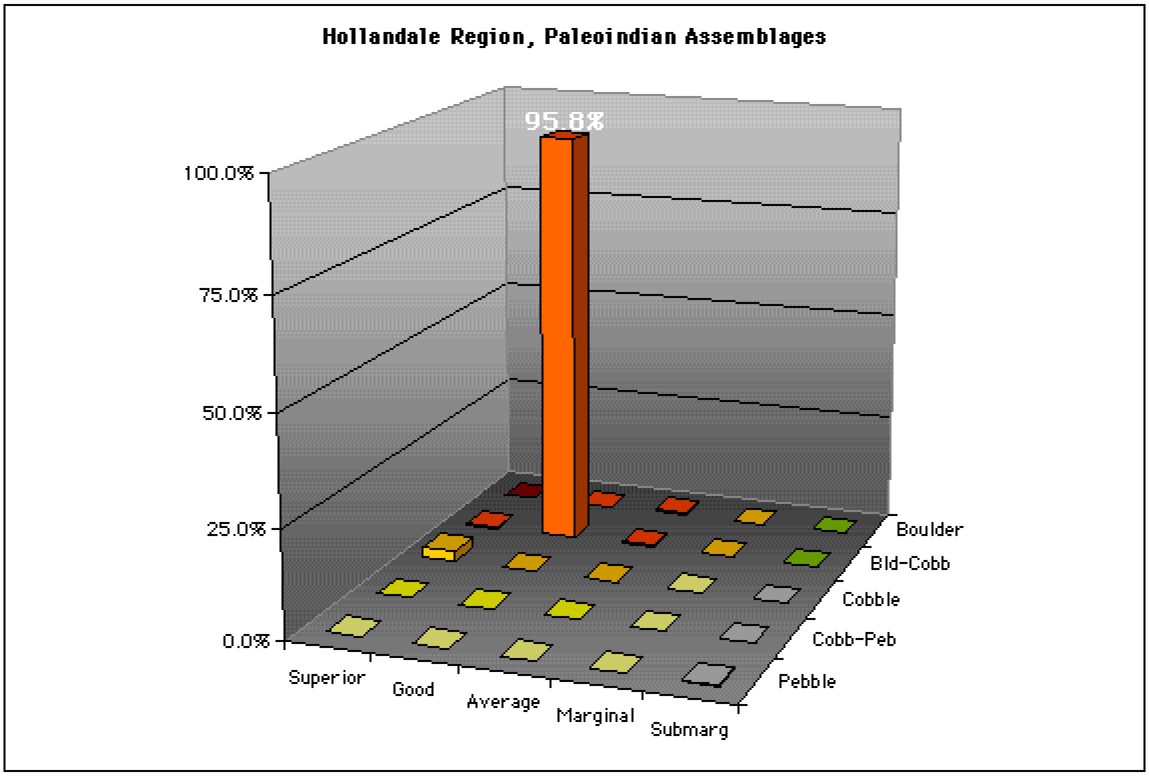
			n=	JTac	Other AkS	total AkS	KLS	Qtz	HBL
Simmonds	DcJh-4	Plano	10,958	90.2	9.4	**99.6**		0.1	
Brohm	DdJe-1	Plano		93.2	1.9	**95.1**		2.8	0.3
Biloski	DcJh-9	Plano		100		**100**			
Cummins	DcJi-1	Plano		98.6		**98.6**			
Widar	DcJi-6	Plano		100		**100**			
Harstone Hill	DcJj-11	Plano		76.3	20.3	**96.6**			
River Terraces	DcJh-38	Plano		95.6	4.4	**100**			
Tower Road	DhJm-6	Plano		99.2	0.2	**99.4**			
Kam Survey		Plano	633	94.8	2.9	**97.7**	0.6	0.3	0.5
Renshaw	DaLi-1	Arch.	349	69.9	6	**75.9**	1.2	13.5	
McClusky	DbJm-2	Wood.	184	26.6	26.6	**53.3**	3.3	19	21.7

JTac=Jasper Taconite; AkS=Animikie Group raw materials; KLS=Knife Lake Siltstone; LoWC=Lake of the Woods Chert; LoWR=Lake of the Woods Rhyolite; Qtz=quartz; HBL=Hudson Bay Lowland Chert.

of connection to the west. Although this may be the case, SRC may be available in the general region of the site; this point is best investigated by additional raw material survey in the area. The BLG Group materials show a different pattern. The percentage of these materials generally remains even in the three oldest components (%=20.1, 22.3, 18.1, Archaic to Late Woodland), while the Historic component contains no BLG materials. KRF also contributes somewhat to changes in UP-1 provisioning, beginning at 7.5 percent in the Archaic component, rising to 18.4 percent in the Middle Woodland, dropping to 11.8 percent in the Late Woodland, and ending near where it began at 8.6 percent in the Historic component. This supports a hypothesis that KRF reaches a peak in distribution in the Middle Woodland (e.g., Clark 1984).

HBLC accounts for some of the provisioning in the UP-3 sector, but the percentage of this material stays relatively even between the components. The changes in the UP-3 sector

Figure 4-31. Utility analysis XYZ depiction of aggregated Paleoindian assemblage data from the Hollandale Resource Region.



are instead largely explained by changes in the percentage of quartz. Quartz occurs at similar levels in the Archaic (%=15.9) and Middle Woodland (%=19.7) assemblages. The percentage rises in the Late Woodland (%=36.5), and is highest in the Historic component (%=45.9). Based on the hypothesis that the use of quartz is – at least in some regions – closely related to bipolar reduction of small raw material stock, these figures would suggest an increasing importance of bipolar reduction through time.

According to Arthurs, however, that may not necessarily be the case. Regarding the Archaic component, Arthurs (1982:113) notes that "Although there is a slight suggestion of bipolar technology, in the cores and detritus, that is not well developed." Regarding the Middle Woodland component, he says that "There is little evidence of the bipolar technique" (Arthurs 1982:117). For the Late Woodland component he notes that "pebble cores are present, and although there is some indication of the bipolar technique, it is by no means as prevalent as on Terminal Woodland sites farther to the east" (Arthurs 1982:135). There

Table 4-19. Summary of selected lithic data from Minnesota flood control investigations sites near East Grand Forks, Polk County, Minnesota. Components are listed in approximate chronological age, when known.

Site / Component	**Age (BP)**	**SRC %**	**RRC %**	**KRF %**	**Quartz %**	**n=**	**Reference**
21PL83 Late Wood.	*Sandy Lake; NEPV?*	20.0	--	40.0	20.0	10	Florin and Wergin 2004
21PL49 Late Wood.		48.1	11.1	7.4	--	28	Florin and Wergin 2001; Florin et al. 2001
21PL72 Mid. Wood?	1152 ± 44	--	--	20.0	40.0	5	Harvey et al. 2005
21PL74 Mid. Wood.	1604 ± 45 1608 ± 35 1494 ± 49 1084 ± 47	17.2	--	34.4	6.2	64	Harvey et al. 2005 Aggregates lithics from two Middle Woodland components.
21PL66 Mid. Wood.	1620 ± 40 1590 ± 40	1.0	--	70.3	--	101	Florin et al. 2001 Includes obsidian
21PL54 Mid. Wood.	1680 ± 40	12.9	7.5	57.0	--	93	Florin et al. 2001
21PL57 Late Archaic	3170 ± 40 3220 ± 40	13.9	--	84.8	--	433	Florin et al. 2001
21PL57 Mid. to Late Archaic	3640 ± 40	--	--	40.7	--	27	Florin et al. 2001
21PL49 Mid. Archaic?	5680 ± 50 5450 ± 40	--	--	--	--	5	Florin and Wergin 2001; Florin et al. 2001
21PL54 Early Archaic	7010 ± 40 7080 ± 40	60.0	30.0	10.0	--	10	Florin et al. 2001
21PL85 cf. Archaic	--	---	--	96.6	--	59	Most lithics small, from tool maintenance; feature context. Florin and Wergin 2004

NEPV = Northeastern Plains Village

do not appear to be any similar statements regarding bipolar reduction in the Historic component.

Arthurs also provide interesting information on other kinds cores in the Archaic and Middle Woodland components. Of the Archaic, he notes that "The majority of cores are random polyhedral in form, although about half as many are prismatic, suggesting that some attempt was made to control the size and shape of the flakes being detached from the cores" (Arthurs 1982:113). About the Middle Woodland component, he says that "The reduction technology is based on the reduction of random polyhedral cores" (Arthurs 1982:117). The mention of random polyhedral forms brings to mind the practice of flintknappers at the Bass (Early Archaic) site (Stoltman et al. 1984:209). The mention of prismatic cores is quite interesting, and should be investigated further; it is not quite apparent what material this reduction strategy was applied to.

21RO21, Erickson

The Erickson site is a single component, Middle Woodland site located on a Glacial Lake Agassiz beach ridge in Roseau County, near the northwestern corner of the state. This falls in the Tamarack Subregion, South Agassiz Resource Region. The site was investigated in the late 1980s (Bakken 1988). The site was identified as Middle Woodland based on the presence of smooth surfaced, grit tempered ceramic sherds that were thought to most likely be Laurel, and on the very high percentage of Knife River Flint (see Clark 1984). It was interpreted to be a brief duration site.

The lithic assemblage from this site consists almost entirely of KRF (549 of 561 pieces, %=97.9). As a result, the XYZ display of the data looks in some respects like a Paleoindian assemblage (Appendix 2: 21RO21). Most provisioning falls in the UP-1 sector (%=98.3), as with the Paleoindian pattern. In this case, however, even without the presence of ceramics or diagnostic artifacts we could most likely rule out a Paleoindian affiliation because of the raw material, and more specifically because the majority of the assemblage is an exotic raw material. Recall that KRF was often present in the Paleoindian assemblages we reviewed, but it never constituted more than a small percentage of the total. The same could be said of any other exotic or nonlocal raw material, since the Paleo assemblages were comprised primarily of local raw materials. In addition, we saw that the Paleo assemblages tend strongly to focus on one of a small number of local materials (e.g., Swan River Chert, Knife Lake Siltstone, Cedar Valley Chert). KRF was not one of the focal materials for these raw material economies.

That is not to say that we would never find a Paleoindian assemblage that was primarily a nonlocal or exotic raw material. In that case, KRF would be a reasonable contender since it was heavily used by Paleoindian populations in parts of North Dakota (e.g., Schneider 1982). These observations, however, are offered because they may be useful as a reminder that an XYZ depiction of lithic data must be interpreted in connection with a fuller look at the data.

Erickson also offers a benchmark for assessing the intensity of KRF use in the Middle Woodland. We already know that many Middle Woodland assemblages in parts of the Upper Midwest display relatively high levels of KRF; Clark (1984) provides a good overview of this subject. In most places, however, percentages are nowhere near this high, with the exception of sites of the sort reviewed above in Polk County. The reason for such high levels at Erickson likely has to do not only with its Middle Woodland affiliation, but also with the fact that it represents a single, brief use of the site. During the brief time – perhaps no more than overnight – that this camp was occupied the flintknappers busied themselves with KRF, which they usually had in hand and in some abundance. If they had stayed a bit longer, or if we could follow them to their next camp, we might well use of a broader range of raw materials, possibly provisioning with local raw materials and a more moderate representation of KRF in their overall lithic economy.

Nevertheless Erickson serves as reminder that at the right kind of site, the lithic assemblage can capture a small sample of the overall raw material economy and a sample that over represents aspects of that economy. Basswood Shores (21DL90; Justin and Schuster 1994), discussed in the introduction to this data presentation section, is another example. Basswood Shores was also a short-duration, single-use site. There the lithic assemblage was composed almost entirely of Maynes Creek Chert, a raw material from central Iowa. Maynes Creek otherwise occurs only in small percentages at archaeological sites in Minnesota. The same sort of issue can occur with a feature that also represents a particular flintknapping episode. 21MA63, discussed above with aceramic and Archaic data, provides an example of this. Recall that both excavation units at the site intersected a flintknapping feature composed almost entirely of Lake of the Woods Rhyolite. The feature overemphasized the importance of the rhyolite in the Brainerd component. In such a case, however, note that the sample also included a more representative sample from outside the feature, and expanding the excavation could have enlarged the more representative sample. Such a strategy would not be an option at sites like Erickson and Basswood Shores. As long as we are aware that this issue can arise with certain kinds of sites and context, however, it should be simple to interpret the associated assemblages appropriately.

Polk County, Minnesota Flood Control Investigations Sites

These sites were introduced above, in the discussion dealing with Archaic and aceramic assemblages, and they are examined again here with closer attention to the ceramic-period evidence. Because much of the prior discussion of these assemblages involved changing levels of use for KRF, it seems appropriate to revisit this evidence in light of the high levels of KRF seen at 21RO21. In the aceramic-section discussion, I asserted that the overall impression created by this series of assemblages (Table 4-19) is of low intensity KRF use in the Early Archaic, with levels rising through the Archaic and reaching an impressive peak in the Late Archaic.

The ceramic-period data from this series includes three better Middle Woodland samples (21PL54, 21PL66, 21PL74), one very small sample (n=5) that might be interpreted as transitional Middle to Late Woodland (21PL72), and two small Late Woodland samples (21PL49, 21PL83). In general terms, these indicate the continued importance of KRF in Middle Woodland assemblages where it occurs in moderate to high levels, and decreasing importance in the Late Woodland, where it occurs in low to moderate levels.

At the Early Archaic component at 21PL54, which is similar in age to Rustad, we saw a pattern much like that seen at Rustad (Appendix 2: 21PL54, 32RI775). The local raw materials Swan River Chert (%=60.0) and Red River Chert (%=30) predominate, and a small amount of Knife River Flint (%=10) rounds out the assemblage. Note that the small size of the sample limits any nuance in the percentage figures. The Middle Woodland component at the site stands in clear contrast. KRF (%=57.0) is the single most common raw materials, while SRC (%=12.9) and RRC (%=7.5) occur in relatively small amounts. 21PL66, with a Middle Woodland component similar in age to that at 21Pl54, shows even higher levels of KRF (%=70.3). It is interesting that this assemblage also includes one of the largest samples of obsidian (n=21, %=20.8) from any site in Minnesota. This would seem to agree with the opinions of some researchers (Anderson et al. 1986; Hughes 2007) that in Minnesota obsidian is most common in Middle Woodland assemblages, if not limited to such assemblages (although the latter does not seem to be the case).

In the Middle Woodland assemblage from 21PL74, we see KRF present at a more moderate level (%=34.4) although this is still relatively high when compared to sites east of

Table 4-20. Percentage of aggregated assemblages found in the UP-2 sector of the utility plane.

Region / Subregion	Paleoindian Assemblages	Aceramic Assemblages	Ceramic Assemblages	Village Assemblages
Minnesota	**0.1**	**6.3**	**9.7**	**18.9**
South Agassiz	**0.1**	**5.9**	**6.6**	**11.9**
Tamarack	0.0	0.2	3.2	--
Upper Red	1.4	13.1	5.9	6.1
Shetek	0.0	10.7	10.3	11.9
West Superior	**0.0**	**10.4***	**12.5***	**--**
Arrowhead	0.0	0.8	0.3	--
Quartz	0.0	22.8*	13.4*	--
Pipestone	**--**	**--**	**--**	**--**
Hollandale	**2.6**	**9.5**	**6.6**	**20.4**

* Indicates data with known sampling or identification problems. Dash indicates that no data are available.

the Red River Valley or sites that are older than the Late Archaic (Appendix 2: 21PL74). SRC is still at low levels (%=17.2), and RRC is absent. Note, however, the presence of a small amount of quartz (%=6.2). The sample from 21PL72, potentially transitional from Middle to Late Woodland, is very small in size and thus difficult to interpret reliably (Appendix 2: 21PL72). This could indicate falling levels of KRF use (%=20.0) and perhaps more interestingly a potential rise in the importance of quartz (%=40.0).

The Late Woodland assemblage from 21PL49 (Appendix 2: 21PL49) also seems to indicate falling importance for KRF (%=7.4) and a corresponding rebound in the importance of SRC (%=48.1) and RRC (%=11.1). Quartz is absent. The Late Woodland assemblage from 21PL83 (Appendix 2: 21PL83) returns to higher levels of KRF (%=40.0) and lower levels of SRC (%=20.0). Quartz, however, occurs at a relatively high percentage (%=20.0). Again this is a very small sample, thus less nuanced in the percentage figures and capable of bearing less weight in interpretation.

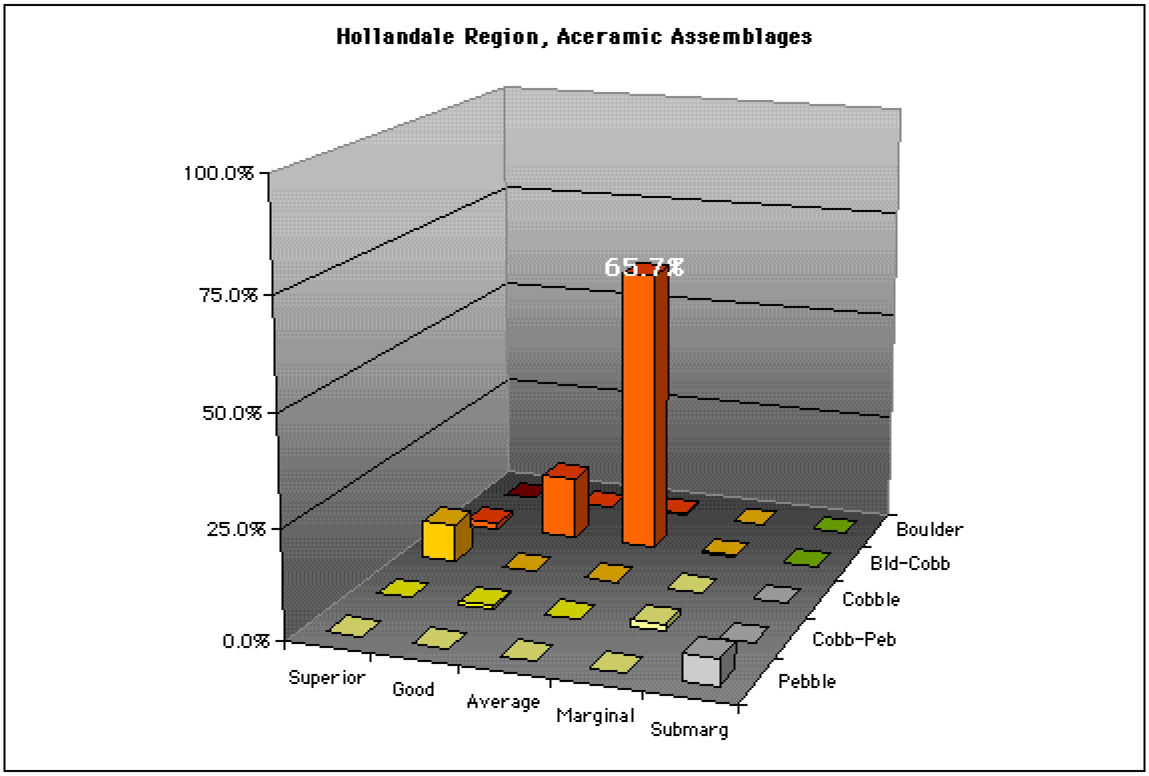
In general, we might summarize the trends in the ceramic-period data in this way. Knife River Flint generally occurs at higher levels in the Middle Woodland; it is present but generally less important in the Late Woodland assemblages. Red River Chert is likely to be present when levels of KRF are low, but absent when they are high. Quartz appears only in the later assemblages, an observation that might prove useful in using raw material composition to potentially diagnose general chronology or cultural affiliation of sites in the region (or subregion).

21KC2, McKinstry

McKinstry is an important mound and habitation site located on the banks of the Rainy River (also the Minnesota-Ontario border), in Koochiching County of north-central Minnesota. This falls along the border between the Tamarack Subregion, South Agassiz Resource Region to the west and the Arrowhead Subregion, West Superior Resource Region to the east. (Note, however, that this section of regional boundary is especially arbitrary, and should not be accorded greater significance than it warrants.) There have been numerous episodes of archaeological work at the McKinstry site, beginning in the late nineteenth century. The information discussed here pertains to 1994 excavations carried out prior to replacement of a highway bridge at the site (Thomas and Mather 1996). These excavations documented a series of components in stratified deposits. The investigators interpret the deposits in terms of four components: Initial Woodland, Early Terminal Woodland, Middle Terminal Woodland, Late Terminal Woodland. (Note that these terms reflect usage in parts of northern Minnesota; Initial Woodland equals the more broadly used term Middle Woodland, and Terminal Woodland equals Late Woodland.) A series of 13 radiocarbon from the 1994 investigations provide the following dates for each of the components: Initial Woodland, 2120 ± 60 to 1570 ± 50 BP; Early Terminal Woodland, 1270 ± 60 to 1200 ± 50 BP; Middle Terminal Woodland, 1130 ± 60 to 970 ± 60 BP; and Late Terminal Woodland, 970 ± 60 to 800 ± 60 BP. The 1994 investigations failed to find older Archaic deposits identified by previous researchers.

If we examine the distribution of this data by UP sectors (Table 4-23; Appendix 2: 21KC2), we can see what appear to be two patterns. In the earlier two assemblages, provisioning in the UP-1 sector averages about 54 percent, while provisioning in the UP-3 sector averages about 40 percent. The opposite is true in the later two assemblages, where provisioning in the UP-1 sector average 40 percent, while provisioning in the UP-3 sector averages about 58 percent. Two important factors in this change would seem to be steadily decreasing percentages of Swan River Chert in UP-1 (%=15.0, 6.7, 4.4, 1.7) and increasing percentages of Hudson Bay Lowland Chert in UP-2 (%=21.9, 20.2, 40.6, 45.2). Other

Figure 4-32. Utility analysis XYZ depiction of aggregated aceramic assemblage data from the Hollandale Resource Region.



materials tend to stay about steady or to fluctuate up and down without any obvious pattern. (Note the lack of raw materials in the UP-2 sector. This is a reminder that, as the raw materials have been placed in the utility plane, there is a regional lack of toolstone in this sector.)

In interpretations by other researchers (e.g., Hohman-Caine and Goltz [1995a], in their discussion of the Archaic in the Headwaters region), this could be taken as evidence for weakening of connections to the west (source area for SRC) and strengthening connections to the east (source area for GFS). Curiously, this pattern is not clear in the percentages of other raw materials.

It is worth noting that KRF is highest in the Initial (Middle) Woodland context (%=4.7), absent from the Early Terminal Woodland, and present in small amounts in the Middle and Late Terminal Woodland assemblages (%=2.5, 1.6). This seems to support the idea mentioned before, of the circulation of KRF being generally high during the Middle

Woodland. Given such relatively low percentages, however, it could be quite challenging to use the levels of KRF as a diagnostic tool. It seems that changes within such a small range might as easily be attributable to sampling issues or other factors. The matter requires closer examination.

One apparent problem with the data for these is the identification of a raw material of Spanish Diggings (Wyoming) or possibly Black Hills (South Dakota) provenience. The investigators acknowledge and discuss the problematic nature of this identification (Hoppin and Mather 1996:12.20). The identification of this material seems dependable, but its presence here still seems odd. That is in part because it occurs in the form of blocky flaking debris and other debitage but no tools, which is contrary to the usual pattern for exotic raw materials. In addition, it seems odd that the material is present in all of the components (with the percentage varying from 0.4 to 9.6). If we hypothesize that this blocky flaking debris represents reduction of pebble-sized raw material stock (rather than, for example, maintenance of an imported biface), we might wonder if it represents use of the Western River Gravels Group resource. Conceivably the WRG Group could include clasts of materials from these sources, although this is not demonstrated. In addition, it is not clear that the WRG Group might be represented in the landscape around McKinstry.

Hoppin and Mather (1996) provide some information on cores and core fragments by component (except for the Early Terminal Woodland, which yielded no cores). Of a total of 28 cores and core fragments, 16 (%=62.5) were bipolar. The Initial Woodland component included 2 core fragments. One of these was bipolar (quartz=1 of 1). The Middle Terminal Woodland component included 10 cores and core fragments. Of these, 5 were bipolar (quartz=2 of 2, HBLC=1 of 3, Gunflint Silica=2 of 2). They also note the presence of utilized bipolar cores, which were missing from the other components. The Late Terminal Woodland component included 16 cores and core fragments. Of these, 10 were bipolar (quartz=7 of 7, Lake of the Woods Rhyolite=1 of 2, SRC=1 of 1, RRC=1 of 1).

The remaining cores are enigmatic. Hoppin and Mather describe a series of small cores (with the largest measurement on a side of about 4 cm, and the smallest 0.8 cm). Most of these seem to be some form of pebble core, but with one striking platform; some of the platforms are faceted. All have at least some cortex remaining on the surface, with percentage of cortex cover as high as about 80 percent. One core has two perpendicular striking platforms, and another has multiple platforms. Raw materials include Gunflint Silica (n=3), HBLC (n=5), and Lake of the Woods Rhyolite (n=3). It is not clear what kind of technology or reduction strategy might be represented by these cores.

Table 4-21. Percentage of aggregated assemblages found in the UP-3 sector of the utility plane.

Region / Subregion	Paleoindian Assemblages	Aceramic Assemblages	Ceramic Assemblages	Village Assemblages
Minnesota	**3.8**	**18.3**	**42.0**	**2.7**
South Agassiz	**3.2**	**21.0**	**27.7**	**13.5**
Tamarack	2.9	28.6	33.3	--
Upper Red	10.9	12.7	27.8	23.2
Shetek	0.4	10.7	23.6	13.5
West Superior	**4.1**	**34.4***	**50.2***	**--**
Arrowhead	4.0	24.4	43.6	--
Quartz	0.1	48.1*	50.8*	--
Pipestone	**--**	**--**	**--**	**--**
Hollandale	**0.0**	**2.2**	**6.4**	**0.1**

* Indicates data with known sampling or identification problems. Dash indicates that no data are available.

21CY39, Ponderosa III

21CY39 is a single component, Late Woodland Blackduck site located on a terrace above the Buffalo River where the river cuts through a Glacial Lake Agassiz beach ridge, in Clay County, Minnesota. This falls in the Upper Red Subregion of the South Agassiz Resource Region. The site was initially discovered in 1981, and further investigated in 1985, 1991, and 2002. The site is interpreted as probably representing a series of sequential, overlapping camps spread along the terrace edge. It is one of the most westerly discoveries of Blackduck, which more commonly is found in lake-forest landscapes. A radiocarbon date of 920 ± 40 BP was obtained from a sample of bone fragments recovered from a pit feature (Michlovic 2005).

The UP-1 sector accounts for 51.8 percent of the assemblage (Appendix 2: 21CY39). Most of this is Swan River Chert (%=38.5), and the rest is KRF (%=13.3). The UP-2 sector accounts for only 4.8 percent, all of it TRS. The UP-3 sector accounts for 26.6 percent, most of it RRC (%=22.8) with a small amount of quartz (%=3.8). The relative importance of UP-3 provisioning stands in contrast with an earlier assemblage like the Middle to Late

Archaic assemblage at 32RI785. In the latter case, the UP-3 sector holds only 2.5 percent (RRC %=1.8, TRS %=0.7). For sites in the South Agassiz Resource Region, one way to look at this is to note the changing the balance between SRC and RRC. In a Paleoindian assemblage like the one from 21RO11, the ratio of SRC to RRC is near 30:1. In the Early Archaic Rustad assemblage, it is closer to 10:1, and in the Middle Archaic assemblage from 32RI785 it is 33:1. Here at 21CY39, the ratio is less than 2:1. This fairly dramatic change suggests that the ratio of Swan River to Red River might provide a regionally useful index for evaluating patterns of raw material use and general site chronology.

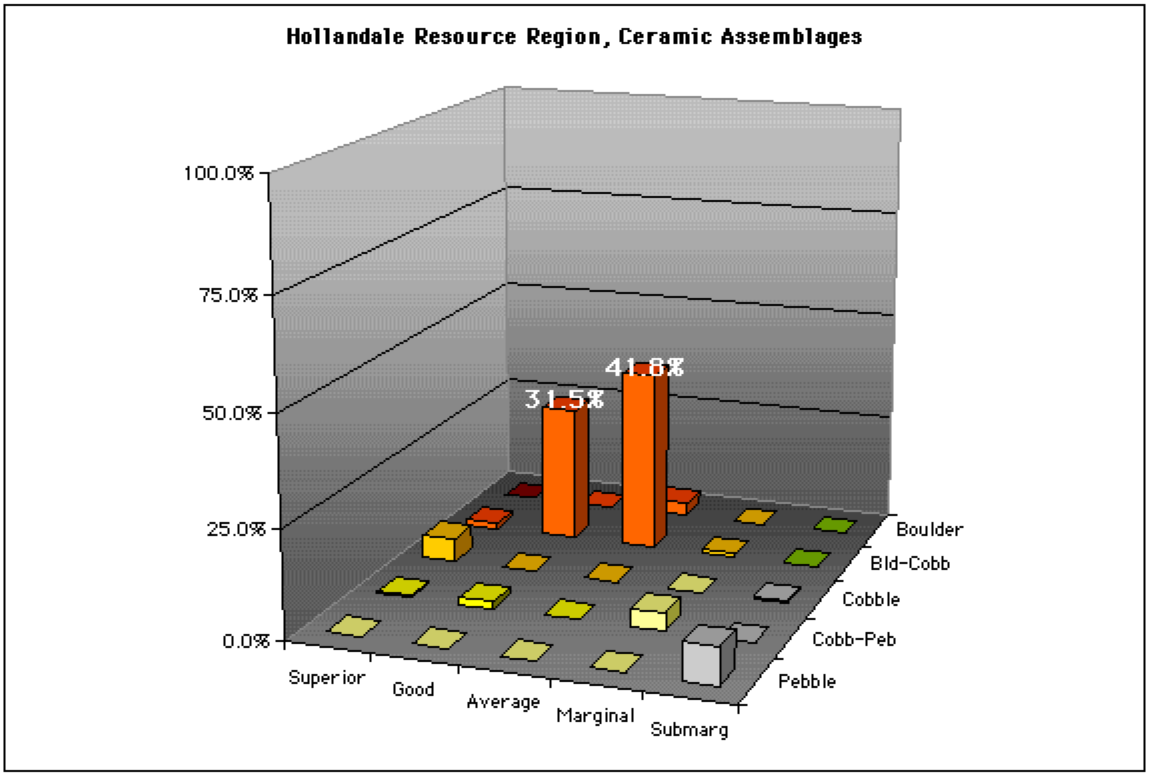
Note also the relatively high percentage of KRF in this Late Woodland assemblage. In contrast, the generally contemporaneous Late Terminal Woodland assemblage from 21KC2 contains only 1.6 percent KRF. This illustrates the falloff in KRF distribution from west to east, a factor that needs to be considered when trying to determine what might constitute low, medium or high levels of KRF in any given area and for any given time period.

21CA198, East Lydick Creek, Area C East

This collection was introduced above, in the presentation of Archaic and general aceramic data. The site is in the Quartz Subregion of the West Superior Resource Region. In Area C East of the site, researchers discovered stratified deposits containing a lower, aceramic and presumably Archaic component, and an upper, ceramic component (Emerson 1996). The latter was associated with sherds comparable to the Bird Lake type (Lenius and Olynik 1990), which suggests a date in the range of about A.D. 1000 to 1650. The data were presented in four parts: surface to 15 cm, 15 to 55 cm (the heart of the Woodland component), 55 to 70 cm (commingled Woodland and aceramic components), and 70 to 100 cm (heart of the aceramic component).

In the lower component, provisioning focused on the UP-2 sector (Appendix 2: 21CA198) and TRS (%=83.9). With SRC (%=14.3), this constituted most of the lithic assemblage. The upper component lacks the tight provisioning focus of the lower component. Provisioning with the UP-1 sector totals 45.0 percent, while in this case no provisioning falls within the UP-2 sector. The UP-3 sector, however, represents 36.6 percent of provisioning. This represents a significant shift toward smaller raw material stock. The materials represented in UP-3 include Hudson Bay Lowland Chert (%=15.2), Red River Chert (%=8.6), and miscellaneous quartz (%=12.8). The UP-1 sector includes 45.0 percent of the assemblage. In this sector, note that Knife Lake Siltstone – which commonly

Figure 4-33. Utility analysis XYZ depiction of aggregated ceramic assemblage data from the Hollandale Resource Region.



constituted around 90 percent of Paleoindian assemblages in this region – is present but constitutes only 3.9 percent of this Woodland assemblage. Swan River Chert is much more abundant that in was in the lower component (%=32.3). KRF is also present in respectable amounts (%=7.4) for a site in the Headwaters region. In the UP-2 sector we again find only TRS, which is present in much smaller proportions (%=14.5) than it was in the lower component.

The upper, Woodland component clearly shows a broader range of provisioning, more nonlocal raw material, and greater raw material diversity. It might also be noted that the lithics from the top 15 cm bear a strong resemblance to the main part of the Woodland assemblage (15-55 cm), with one noticeable difference. Quartz increases from 12.8 percent in the main part of the Woodland assemblage to 23.1 percent in the top 15 cm. A similar increase in quartz was seen in the uppermost levels (sometimes just on the surface) at a number of sites. The reasons for this are not entirely clear, but we might consider that possibility that quartz continues to increase in importance until late in the era of flintknapping in the region.

32SN246, Naze

Naze is a multicomponent site located on the riverbottom of the James River in Stutsman County, east-central North Dakota. Although raw material resource region boundaries have not been explored for North Dakota, this location should fall within the South Agassiz Resource Region, but probably beyond the limits of the Upper Red Subregion. If this is the case, we would expect local raw material resources to be generally similar to other parts of the South Agassiz Resource Region, with differences in relative abundance, and the possible addition or subtraction of a small number of materials. The site was discovered in 1976, and more intensively excavated in 1985 (Gregg 1987b). An Early Plains Woodland component included the remains of a burned earth lodge; this component dated to around 550 to 410 BC. A Middle Plains Woodland component dated to around 40 BC to AD 70. It was associated with the Sonota complex, and appeared to represent recurring use as a base or field camp. A Plains Village component dated to about AD 1100 and 1400, and was associated with intensive habitation and some kind of residential base. The part of this upper component that was in the plowzone also contained a small admixture of artifacts associated with protohistoric use of the site in the period of about AD 1750 to 1850; this probably represents the presence of the Yanktonai Dakota at the site.

Note that the Naze site is closer to the Knife River Flint primary source area than the other sites discussed in this thesis, and also within the KRF secondary source area (Gregg 1987a). Thus we can expect to see relatively high levels of KRF in all components at this site. In fact this is the case. KRF levels in both the Early and Middle Plains Woodland components are around 76 percent, and in the Plains Village component around 65 percent. Swan River Chert is slightly more important in the Plains Village assemblage (%=16.4) than in the Early (%=10.9) or Middle Plains Woodland (%=12.0) assemblages. In addition, the percentage of unidentified or generically identified raw materials increases somewhat in the Plains Village (%=13.9) component compared to the Early (%=4.5) and Middle Plains Woodland (%=6.3) components.

Although these numbers do show some change in raw materials provisioning between the Plains Woodland and Plains Village components, they also point to something of a problem. This type of analysis seems to work reasonably well when the main sources of toolstone are

Table 4-22. Distribution of assemblage between UP-1, UP-2 and UP-3 sectors for the Long Sault site, DdKm-1.

Component	**UP-1** %=	**UP-2** %=	**UP-3** %=	**Unidentified, Generic IDs** %=
Historic	32.3	-	62.3	6.4
Late Woodland	48.2	-	47.6	3.2
Mid. Woodland	63.8	-	29.7	3.8
Archaic	67.8	-	28.1	2.4

glacial sediments containing multiple raw materials that vary in flaking quality and package size. In areas where toolstone mostly comes from sources that offer lots of one kind of stone – primary geologic sources (e.g., in parts of the Hollandale Resource Region) or expansive lag deposits (e.g., the KRF primary source area) – this type of analysis is less informative. That is not to say that nothing can be learned in such contexts. It seems, however, that variations are likely to be more subtle, and that issues of sample size and site contexts require more careful attention.

The researchers do note a change in raw materials and technology between the Early and Middle Plains Woodland on one hand, and the Plains Village on the other. This includes a reduction in the intensify of KRF use in the Plains Village assemblage as noted above, although they still posit direct access to the KRF quarries by this population. It also includes the appearance of bipolar core reduction. The timing of this appearance is interesting, as data from other sites examined in this thesis show that bipolar pebble reduction is more common in Woodland sites (and probably present in *some* earlier assemblages). One possible reason could be easy access to large amounts of KRF, which would mitigate the need to use small pieces of local raw materials. In any case, this serves as a caution that bipolar pebble reduction (with the associated shift of provisioning into the UP-3 sector) at different times in different places and under different circumstances. Tracking such changes would seem to be a potentially interesting topic for further research.

Observations by Other Researchers

Gonsior and Radford (2005) provide a very interesting set of observations regarding bipolar pebble reduction in the Red Lake basin of the Tamarack Subregion, South Agassiz Resource Region. At the Waskish site (21BL2) they discovered a lithic workshop emphasizing the bipolar reduction of Red River Chert pebbles. They note that

> The Woodland activity area is intriguing in that it appears to represent a localized pattern or phenomena in the Red Lake basin. The regional landform is the Glacial Lake Agassiz lakebed, and lithic materials are apparently difficult to procure locally, with only small pebbles being available along the shoreline in reworked lake sediments. This apparently did not dissuade Late Woodland peoples from utilizing the relatively small Red River Chert pebbles that were available. The Waskish site appears to be similar to other precontact sites in the Red Lake basin because it contains few lithics, and a pattern of using what is available, including pebbles (Les Peterson, personal comm. 2000). The Red River Chert pebbles that were used appear to be between 2.0 and 5.0 cm in size based on the dimension of 10 bipolar cores (Figure 18) and 15 unmodified pebbles (Figure 19) that were recovered from the activity area. [Gonsior and Radford 2005:42]

This evidence adds support for the idea of bipolar reduction of pebbles as an important technology in the Woodland. It is also interesting in that it provides at least a local explanation of the reasons for adopting such a technology. It does, however, also raise a couple of questions. It is not unreasonable to think the resource base in earlier periods also consisted principally of pebbles, which raises the question of how earlier populations dealt with this situation. It is not hard to imagine that a Paleoindian population could cope by bringing in large bifaces (and likely other tools), which would not only have a relatively long use life but also serve as a source of useable flakes. It seems that the same would be true for Archaic populations, however. In that case, did the Archaic populations have dependable provisions for getting toolstone from outside of the area, whether by direct procurement or some kind of exchange? Did they perhaps adapt their technology to make fuller use of pebble-sized stock, thus anticipating by hundreds to thousands of years the hypothesized adaptation by widespread populations in the Woodland? Such questions deserve closer investigation, and could be illuminating in terms of understanding the bigger picture of lithic technology and raw material use.

For the neighboring Arrowhead Subregion, West Superior Resource Region, Mulholland and Shafer (2000:60) note that

> In northeastern Minnesota the use of Hudson Bay Lowland Chert is often best, though not exclusively, associated with Woodland period sites (Mulholland, in preparation). During both the Initial and Terminal Woodland periods this lithic material was used extensively. Not enough data are available at this time to suggest any frequency variations between either period's lithic assemblage.

Given such an observation, we should consider the degree to which the level of HBLC might be useful as an indicator of approximate age for assemblages lacking diagnostic artifacts or absolute data. Ongoing research by Mulholland promises to provide additional information on HBLC use and affiliations.

Mulholland et al. (2008) reiterate the association of HBLC with Woodland sites, and note that the same is also true for Lake Superior Agate. Harrison et al. (1995:21) add Gunflint Silica to the list, noting that

> The flaking properties of smaller, uniform pieces are excellent, however, and tools like small scrapers are frequently found on northern Minnesota sites, particularly on those dating from the later prehistoric period where the use of a bipolar technology allowed for the manufacture of smaller tool types out of smaller chunks of raw material....

For the other end of the study area, Ballard (1984:5) offers an observation regarding raw material use in the upper Skunk River Valley of Iowa. This is in the southern end of the South Agassiz Resource Region. He notes that "Exploitation of glacial erratic cherts tends to be more extensive at sites located relatively distant from Mississippian outcrops.... Late Archaic and Woodland peoples appear to have been the principal users of these chert types."

To this we can add an observation by Morrow (1994:119) regarding northern Iowa, and thus potentially pertinent to parts of the Pipestone, South Agassiz and Hollandale resource regions. He notes that "Grand Meadow chert is found in small amounts on sites in the northern half of Iowa. It seems to have been most extensively used during the Late Woodland and Late Prehistoric periods."

Summary

In the Woodland and general ceramic data, we see provisioning expanding yet again, beyond the UP-1 and UP-2 sectors into the UP-3 sector. This equates with the use of raw material stock of smaller package size. In some cases this involves the regular use of raw materials that were little used before. Examples include such materials as Lake Superior Agate, the Western River Gravels Group and, at least in some areas, quartz. However, this can also involve increased use of raw materials that were regularly used. Red River Chert is one likely example. Its previous use probably reflected reduction of the relatively less common larger pieces (i.e., small cobbles) of RRC. Its increased use probably reflects reduction of the much more abundant pebbles of the same material.

There is evidence that this increased use of small package size materials is tied to bipolar reduction of pebbles. The desired product of this reduction strategy is not clear. It may simply be sharp flakes that can be used as expedient tools. The presence of apparently utilized bipolar cores noted above for McKinstry suggests that the cores themselves could also have served as tools. This reflects a long standing controversy over bipolar cores as simply cores, or as tools and the primary intended reduction product (e.g., Binford and Quimby 1963; Dickson 1977; Hardaker 1979; Hayden 1980; Honea 1965; Jeske 1992; Jeske and Lurie 1993; Kobayashi 1975; Leaf 1979; Shott 1989, 1999; Tomka 2001; White 1968). Although such questions should be resolvable by careful study of artifacts and assemblages, the matter is beyond the scope of this thesis.

There is some evidence for some sorts of bipolar reduction in earlier assemblages, but it appears to be more important in the more recent assemblages. The timing for such an increase in importance is not clear. Some evidence suggests that the timing varies, in fact. While this sort of bipolar reduction seems to be important in at least Late Woodland assemblages over much of the study area, evidence from the Naze site (closer to the Knife River Flint primary source area) indicates that it was not more common in that area before Plains Village assemblages. Closer examination of the timing of this change should provide an interesting venue for future research.

Researchers also note the presence of other kinds of cores. These include random polyhedral cores, potentially of the same kind seen in earlier Archaic and aceramic assemblages. At McKinstry, the researchers also note the presence of small, enigmatic cores with single striking platforms. These hint at the existence of diverse industries and reduction strategies.

Regarding the circulation of exotic and other nonlocal raw materials, we have good information regarding Knife River Flint. The situation is not clear for the Early Woodland, but KRF circulation in the Middle Woodland is very intensive and at least moderately extensive. This may simply be a continuation of the intensive circulation seen in the Late Archaic, although the matter requires closer examination. After the Middle Woodland, KRF circulation diminishes in the Late Woodland, and probably (with exceptions) in village culture traditions also. There may also be a further drop in the protohistoric period. The situation is not as clear for other materials, although there seems to be greater low-intensity circulation of multiple materials between regions than was seen in previous periods and patterns.

The expansion of provisioning to smaller raw material stock, together with the potentially greater inter-regional circulation of nonlocal raw materials, leads to greater raw material diversity in the Woodland and general ceramic assemblages. Closer quantification of this diversity might provide a useful index for examining the approximate chronology of lithic assemblages lacking absolute dates or diagnostic artifacts.

The evidence reviewed so far seems to suggest three discernable raw material provisioning and use patterns, each associated with a different sector in the utility plane, and also with different reduction strategies. This brings us to the point of examining the final broad set of data, that associated with the various village cultures.

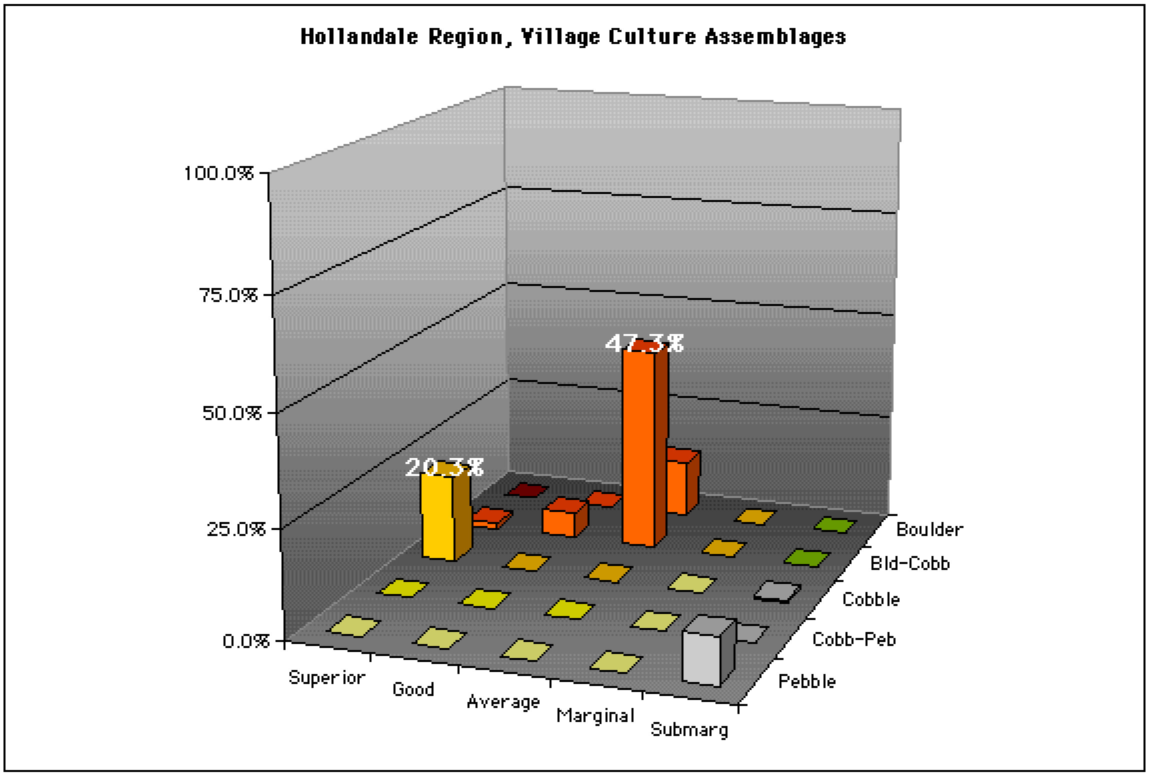
Village Culture Data

Aggregated Data

The aggregated village culture data is a bit hard to evaluate, for a couple of reasons. First, village cultures are essentially absent from most of central and northern Minnesota. This limits the size of the sample and the comparative data set, compared to the aggregated data sets discussed above. Second, it is not always clear what constitutes a village-culture site and therefore a village-culture assemblage. Obviously the major villages themselves qualify, but what about smaller sites with a mixture of village and Woodland ceramics? Finally, technical problems prevented access to some relevant data. Fore these reasons, this discussion of the aggregated village-culture assemblage is preliminary and somewhat tentative. In addition, within Minnesota the Hollandale Region seems to offer the best village-culture data so the evidence from that region is the general focus of the following discussion, although it is possible to find some data for the Shetek Subregion also. Outside of the state, some good information was found for North Dakota, and that is included in this discussion.

Broadly, the village-culture assemblage seems to resemble the ceramic assemblage (Tables 4-7, 4-8, 4-10, 4-13). XYZ graphs for Woodland-ceramic and village data (Figures 4-6, 4-10, 4-17, 4-21, 4-34), for example, tend to resemble each other more than either resemble graphs for aceramic-Archaic data. The Hollandale data (Figure 4-34), however, points to three potential differences that might prove to be significant. First, it looks like provisioning pulls back somewhat from the UP-3 sector (ceramic %=6.5, village %=0.2). In this case, the UP-1 sector also loses share (ceramic %=78.0, village %=68.0) and a substantial gain appears in the UP-2 sector (ceramic %=6.7, village %=20.3). Data from other regions suggests, however, that the latter two particulars may be features of the Hollandale region rather than the pattern, and that the important change is the pullback from the UP-3 sector.

Figure 4-34. Utility analysis XYZ depiction of aggregated village culture assemblage data from the Hollandale Resource Region.



More specifically, it seems that some of the marginal quality materials like quartz and Tongue River Silica, present in at least small amounts in the ceramic assemblages (quartz %=4.1, TRS %=0.9), mostly disappear from the village-culture assemblages (quartz %=0.1, TRS %=0.0). Pebble-sized raw material stock in general probably falls largely out of use. This also means that village-culture assemblages may be somewhat less diverse. In other words, for a given size sample they contain fewer raw materials. Second, Hixton Group quartzites increase in importance in the village-culture data (ceramic %=2.3, village %=13.5). Finally, Grand Meadow Chert also appears to increase in importance in the village-culture (ceramic %=5.6, village %=20.3).

In the Shetek Subregion, South Agassiz Resource Region (Figure 4-21), there seems to be the same pullback from the UP-3 sector (ceramic %=22.7, village %=13.5). In this case the main gain is in the UP-1 sector (ceramic %=51.7, village %=57.9), while the UP-2 sector shows a small gain or remains essentially at the same level (ceramic %=10.4, village %=11.9).

Table 4-23. Distribution of assemblage between UP-1, UP-2 and UP-3 sectors for the McKinstry site, 21KC2.

Component	**UP-1** %=	**UP-2** %=	**UP-3** %=	**Unidentified, Generic IDs** %=
Late Term. Woodland (n=1,705)	40.4	-	57.2	1.3
Middle Term. Woodland (n=799)	39.7	-	59.0	0.0
Early Term. Woodland (n=178)	56.1	-	42.2	0.3
Initial Woodland (n=233)	52.3	-	38.7	0.5

In contrast to the Hollandale data, more than incidental provisioning remains in the UP-3 sector. The greatest change is in decreased use of quartz (ceramic %=16.6, village %=7.9), although other UP-3 sector raw materials also tend to decrease. There may also be a small increase in the importance of Grand Meadow Chert here (ceramic %=1.9, village %=6.3), although this should be checked based on data from a larger number of sites and assemblages. There may be some increase in level of use of Knife River Flint (ceramic %=3.1, village %=6.3), although this again should be checked. An increased importance of Hixton Group quartzites is not apparent, since it is of minor importance in both aggregated assemblages.

32CS101, Shea

The Shea site is a fortified village overlooking the Maple River in Cass County, southeastern North Dakota. This location falls within the Upper Red Subregion of the South Agassiz Resource Region. The site is located on Glacial Lake Agassiz beach deposits; these and glacial sediments outside the Agassiz basin could have served as sources of toolstone. Shea was investigated in the 1980s (Michlovic and Schneider 1988, 1993). The site was inhabited periodically in the mid-fifteenth century; a series of radiocarbon dates average AD 1448. The site yielded substantial amounts of both Northeastern Plains Village ceramics and Sandy Lake ware, and a small amount of Oneota. The Sandy Lake vessels establish connections to

Woodland populations to the east, while the Oneota vessels establish connections to village cultures to the south and southeast.

In examining the raw material profile of the Shea site assemblage (Appendix 2: 32CS101), we encounter a complication. In addition to yellow-red Tongue River Silica, the assemblage includes both smooth grey (n=259, %=14.5) and coarse grey TRS (n=55, %=3.1). Because these are rare in the overall data st, they are not accommodated in the spreadsheets used to apply a standardized utility analysis, and their location in the utility plane was also not considered. It is probably safe to include the coarse grey variety with the more commonly encountered yellow-red TRS, since a preliminary review suggests they have similar characteristics in terms of flaking quality and package size (see Ahler 1977; Porter 1962). The smooth grey variety, however, apparently has better flaking quality and should find a home in the utility plane closer to the centrum. For the purposes of examining the Shea data, smooth grey TRS is tentatively assigned to the cell at the intersection of boulder-cobble size and average flaking quality. This places it in the UP-1 sector.

One other caveat should be noted. The apparent absence of Red River Chert from the assemblage (and the generally low raw material diversity) seems unusual. It may be that RRC is subsumed in the "other chert" category, potentially along with other types of identifiable cherts occurring in small percentages. Even if this is the case, however, the Shea data are still informative.

The data from Shea suggest a couple of possible trends in village culture lithic assemblages. First, note the decrease in quartz (%=0.2) compared to nearby Woodland sites like 21CY39 (%=3.8) or 21NR29 (%=6.4). The second is a increase in the amount of Tongue River Silica (%=16.3 for 32CS101, %=4.8 for 21CY39, %=10.6 for 21NR29). It is interesting to note that at Shea this increase is not based on local resources, but represents the use of nonlocal grey TRS from sources to the west (cf. Ahler 1977). Some of this is better quality smooth grey TRS, but some is also the relatively poor quality coarse grey TRS.

A casual aggregation of data from sites in eastern North Dakota supports these possibilities.[5] A review of assemblages from Stutsman and Lamoure counties (Gregg et al. 1987; Picha and Gregg 1987) does seem to show a tendency towards lower amounts of quartz and increased amounts of grey TRS in Plains Village assemblages. These data deserve a closer

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5. These data are not presented in detail since they contain a somewhat different variety of raw materials and do not fit easily into the standardized analysis used for all the other assemblages reviewed in this thesis; the paragraph above discussing treatment of grey TRS in the Shea site assemblage provides an example of the kind of problems encountered.

review, however, in the context of a localized analysis based on adapting the utility analysis to the somewhat different resource base in that area.

32SN246, Naze

The multicomponent Naze site was introduced above, in the discussion of Woodland and ceramic assemblages. This site included a Plains Village component dating from the period of about AD 1100 to 1400 (Picha and Gregg 1987). That component is briefly re-examined here by way of comparison with other village culture assemblages. In terms of raw material use, KRF levels in the Early and Middle Plains Woodland components are around 76 percent, while in the Plains Village component around 65 percent (Appendix 2: 32SN246). Swan River Chert is slightly more important in the Plains Village assemblage (%=16.4) than in the Early (%=10.9) or Middle Plains Woodland (%=12.0) assemblages. In addition, the percentage of unidentified or generically identified raw materials increases somewhat in the Plains Village (%=13.9) component compared to the Early (%=4.5) and Middle Plains Woodland (%=6.3) components.

The researchers note the appearance of bipolar core reduction in the Plains Village component. The timing of this appearance is interesting, as data from other sites examined in this thesis show that bipolar pebble reduction is common in Woodland sites (and probably present in some earlier assemblages). This could be connected to the increase in levels of unidentified or generically identified raw materials, if these materials represent a diverse set of glacially and fluvially distributed pebbles.

21GD3, Silvernale

Silvernale is a major village and mound group at the juncture of the Cannon and Mississippi rivers in the city of Red Wing, in Goodhue County, southeastern Minnesota. The locations falls in the Hollandale Resource Region. The site has been investigated repeatedly since the late nineteenth century; the results reported here come from work by Schirmer in 2003. The lithic assemblage (n=3,351) comes from general levels of excavation units, and does not include features (Schirmer 2004).

The most common raw material in the assemblage is Prairie du Chien Chert (%=46.6), which is locally available (Appendix 2: 21GD3). The next most common materials, Grand Meadow Chert (%=24.8) and Hixton Quartzite (%=13.0), come from somewhat more distant sources. (Schirmer, citing sources that were not readily available, notes that these are the predominant materials at all known Silvernale Phase Red Wing sites.) The remainder of the assemblage consists mostly of unidentified or generically identified materials (%=12.7), with a smattering of other materials.[6] This places most of the provisioning in the UP-1 sector (%=61.7), with a substantial amount also in the UP-2 sector (%=24.8). It is interesting that none of the provisioning is in the UP-3 sector. This contrasts with the pattern we see in the aggregated Woodland and general ceramic data for the Hollandale Resource Region, where a small but definite amount of provisioning occurs in the UP-3 sector, and where Hixton is uncommon.

Schirmer (2004:8) notes that the assemblage contained about the same number of tools made of Hixton and Grand Meadow, but that

> Hixton was primarily used for projectile points while Grand Meadow seems to be more generally utilitarian, used for points, scrapers, etc. Interestingly, Grand Meadow comprises a significantly larger amount of the chipping debris than Hixton, perhaps reflecting its more general usage as well as the closer proximity of its source.

This suggests possible geographic and functional elements for the differences seen between the two raw materials. Another possibility could be considered, however. It might be interesting to see this data separated by provenience, and to investigate whether there was any complementary separation of Hixton and Grand Meadow, or whether the two seemed to be generally commingled. The same line of investigation might be applied to data on lithics in features (not included in these counts). This could address a question of whether two distant raw material sources were supplying toolstone at the same time, or whether they were used at different times. The latter might provide some interesting insights on changing territories or alliances.

47LC34, Valley View

The Valley View site is a palisaded Oneota habitation on a terrace overlooking the LaCrosse River about 6 km (4 mi) above its confluence with the Mississippi River, in LaCrosse County, southwestern Wisconsin. This falls in the Hollandale Resource Region. The information examined here comes from an analysis by Withrow (1983) of materials recovered by salvage

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[6] Note, however, Schirmer's (2004:8) comment that "A significant amount of diversity in the lithic assemblage is masked by the 'unidentified' taxon." It may be that part of this diversity is a small amount of provisioning in the UP-3 sector.

excavations in 1979 by the University of Wisconsin–LaCrosse. The lithic data comes from about half of the excavated features. Radiocarbon dates of 755 ± 85 BP and 930 ± 40 BP were associated with two features; a few contact period artifacts were also found in the plowzone. The full set of data presented by Withrow are not used here because raw material counts could not be reconciled for all artifact subsets. The data set reviewed here represents roughly half of Withrow's total sample; raw material profiles appear to be very similar for both the total sample (based on Withrow's charts and graphs) and the subset used here.

The most common raw materials in the assemblage is the locally available Prairie du Chien Chert (%=84.2). The second most common raw material is Burlington Chert (or what Withrow calls Burlington/Keokuk; see Morrow 1984a, 1994), which constitutes 9.7 percent of the assemblage. The other identified exotic is Hixton Quartzite (%=1.9). It is interesting that Galena Chert – potentially available in large amounts, and from sources much closer than the Burlington sources – is present only in small amounts (%=2.2), while Grand Meadow occurs at a level of less than 0.1 percent (n=2 of 4251). Given the date of the report, it is likely that other regional raw materials might occur in small amounts but were not specifically recognized.

In this assemblage, provisioning occurs almost exclusively in the UP-1 sector (%=98.0); provisioning in the UP-2 and UP-3 sectors amounts to less than 0.1 percent each (Appendix 2: 47LC34). As for the Silvernale site, this contrasts somewhat with regional Woodland and general ceramic data that indicate at least some provisioning in the UP-3 sectors (and the more common provisioning in the UP-2 sector).

Withrow notes the presence of unidirectional, multidirectional, bifacial and bipolar cores in the assemblage. Two unidirectional cores each had a single flake removal, which raises the question of whether they might be better classified as tested cobbles. Three multidirectional cores were described as small. The bifacial cores were distinguished from regular bifaces based on characteristics of width-to-thickness ratio, patterning, and size of flake scars. Nine bipolar cores were identified, all of Prairie du Chien Chert. It is interesting to note here the use of bipolar reduction on the predominant raw material and not, as in other assemblages we have reviewed, on pebbles.

Observations by Other Researchers

Ahler (1977) presents an interesting discussion that follows up on suggestions originally made by Lehmer (1954) regarding differences in raw material use between the Middle Missouri

Tradition and Coalescent Tradition in the Dakotas. Ahler's paper is especially valuable in relating the archaeologically-occurring raw materials to regional geology. Although he uses assemblages from only four sites, clear patterns do seem to emerge. Ahler's four sites are all in north-central South Dakota, whereas Lehmer's were near the Oahe dam in central South Dakota. The Middle Missouri assemblages date to the eleventh century AD, and the Coalescent assemblages to somewhere in the range of the fourteenth to sixteenth centuries.

The results show that both populations made extensive use of locally available raw materials, including those available from alluvial gravels and glacial sediments. Beyond that, however, the earlier Middle Missouri populations depended heavily on Knife River Flint, some probably obtained from local fluvial gravels but much of it clearly coming from the primary sources to the northwest (over 150 km distant). In contrast, the Coalescent populations used only small amounts of KRF, but depended to a large degree on raw materials from to the southwest in and south of the Black Hills (over 300 km distant). Ahler (1977:148) adds the interesting observation that

> Inter-tradition differences are not so much a matter of trade versus the use of local resources as suggested by Lehmer (1954:131) but, rather, there seems to emerge a consistent within-tradition selection for specific source areas regardless of the location of particular archaeological sites. All Coalescent Tradition sites examined show a consistent dependence on southerly occurring materials, and all Middle Missouri Tradition sites show a consistent selection for Knife River Flint, in each case, regardless of the distance and directions from the sites to the sources.

Picha and Gregg (1987:185) provide a series of observations on changing levels of KRF use:

> Schneider [1982:Table 2] reported a decrease in the frequency of occurrence of both Knife River flint (KRF) stone tools and flaking debris through time in a series of lithic assemblages from the study area. KRF makes up 85% of the aggregate from testing the Middle Plains Woodland Sonota component in 1976. However, this overall figure for KRF drops to 37% for stone tools and 22% for flaking debris for late Plains Village components. Concomitantly, frequencies of locally procured quartzites and cherts appear to increase.
>
> Elsewhere on the Northern Plains, KRF has been reported to comprise a large percentage of stone tool assemblages which date to the Middle Plains Woodland period. There are very high percentages of KRF in Sonota components in both North Dakota and South Dakota (Neuman 1975:80, 91).

Picha and Gregg (1987:225) further note that "The extent of KRF utilization among certain groups in the Northern Plains decreased markedly at about the midpoint of the Plains Village period. The drop-off in KRF use continued into protohistoric and historic times (cf. Ahler [1977]; Johnson 1984; Schneider 1972, [1982])." They summarize a number of suggested reasons for this, including

> Friendly group interaction and exchange may have declined as a result of increased competition between groups for food resources. Protohistorically, groups from the east intruded into the Plains in response to pressures of European exploitation. Historically on the Northern Plains, increased village sedentism and less travel to lithic source areas may have resulted from intensive native participation in the fur trade (Johnson 1984). Semisedentary Plains Villagers lost control of their extensive territories due to immigration of sometimes hostile nomadic groups such as the Middle and Western Dakota. These factors may have led to situations which denied or severely limited Plains Villagers access to the primary source areas for certain nonlocal raw materials such as KRF and smooth gray TRSS.

For the southern part of the current study area, Morrow (1994:123, 128) offers a couple of brief observations. First he notes that "White Burlington chert was also widely circulated among Oneota groups during the Late Prehistoric period." Later he also observes that "Artifacts of Bijou Hills silicified sediment are often found in northwest Iowa where they appear to be most commonly associated with Oneota sites. It is unusual to see this material in other parts of the state."

Summary

In summary, the village culture data looks broadly similar to the general ceramic and Woodland data, and less like either the Paleoindian or aceramic-Archaic data. Still there seem to be some differences between the village data on one hand, and the general ceramic and Woodland data on the other, and these differences might prove to be important. These differences center around a contraction of provisioning as seen in the in the utility plane, with activity moving out of the UP-3 sector and into the UP-2 and UP-1 sectors. As a result, there is some drop in the use of raw materials representing the smallest toolstone stock and also in materials of poorer flaking quality.

This is not, however, a retrenchment to the UP-1 and UP-2 patterns seen in the Paleoindian data or Archaic and general aceramic data (or the XYZ analyses for this different data sets would tend to look more alike). Rather it seems more to be, in a sense, a strategic shift towards certain major raw material sources. This does not mean that local provisioning was abandoned; quite the opposite is true. Local provisioning still remained vital. But a certain amount of provisioning was focused on what we might call "strategic" sources. In addition, these strategic sources could – and apparently did – change through time.

It seems that we can tentatively identify some of these sources. For the Hollandale

Resource Region, and thus southeastern Minnesota and west-central Wisconsin, one such source was probably Silver Mound, which would have served in practical terms as a source of nearly unlimited amounts of large pieces of Hixton Quartzite. Note that the source is not especially close to the sites it provisioned, being on the order of 100 km (depending on which sites we consider). Another such potential source is the Grand Meadow quarry complex, which would have served as a source of large amounts of Grand Meadow Chert, mostly in the form of cobbles. In this case, the raw material source might also be on the order of 100 km away from the sites it was provisioning. The assemblages from the Valley View site (and other sites noted by Withrow [1983] suggests that Burlington Chert should also be added to this list. Although varieties of Burlington can be found over a relatively broad area of southeastern Iowa, northeastern Missouri and west-central Wisconsin, extensive quarries of high-quality Burlington are found in the vicinity of St. Louis (Ives 1975). The closest sources are on the order of 500 km (300-plus miles) to the south.

To the west, work by Ahler (1977) suggests two other potential strategic sources. The first is the Knife River quarries of west-central North Dakota which could have, in practical terms, again served as a source of essentially unlimited large cobbles to small boulders of Knife River Flint. Yet again we see that the source is at a distance, this time closer to 200 km from the sites Ahler looks at. The second potential source is outcrops in southwestern South Dakota including the Black Hills, which could have provided multiple raw materials of different sizes, configurations and flaking qualities. This time the sources are more on the order of 300 km away from Ahler's study sites.

Finally to the south, passing comments by Morrow (1984a, 1994) hint that we consider the Bijou Hills Quartzite sources in South Dakota and the Burlington Chert quarries around St. Louis (also mentioned above) as further contenders.

It is not clear how sources were chosen or exactly how they were strategic. Proximity was clearly not the consideration, give the relatively great distances between sources and some of the sites they provisioned. Package size also does not seem to be a crucial factor, given the variations seen between the various raw materials. Flaking quality may have been a consideration, although this too seems to vary between the potential strategic sources. One thing the various sources may have in common, however, is that they could have provided very large amounts of toolstone from a relatively restricted area. This certainly stands in contrast with what we might generally expect from glacial sediment sources, with low concentrations but wide distributions. How this abundance and concentration might have provided enough advantage to offset other factors (such as distance) is a matter for further consideration. And we should also consider whether there might have been social factors involved – strategic alliances, for example – although this too is a matter beyond the scope of the current research.

In the preceding examination of data, we had the opportunity to try using a utility-based analysis with lithic assemblages from various regions and time periods. To the extent that such analysis succeeded, it has provided a somewhat different perspective on raw material use, and an approach that is more consistent between different sites, regions, and time periods. The final step in exploring this method of analysis is to work from the results presented in this chapter and attempt a broader synthesis. That, along with an examination of apparent strengths and weaknesses of the analysis, is the topic of the following and final chapter. That chapter concludes with some consideration of directions that this type of analysis might take in the future.

CHAPTER 5. DISCUSSION AND CONCLUSION

The statement "more work needs to be done" is something of
a standard conclusion in archaeological reports.
— J. Steinbring and A.P. Buchner (1980)

In the preceding chapter we reviewed numerous sites, raw materials, percentages, resource regions, observations, and other bits of information. In the midst of such a thicket of detail, it can be easy to loose sight of the big picture. But the big picture is the goal of all this examination. So, from all the detail can we abstract something broader, something more useful and usable, about raw material use, patterning in raw material use, and changes in raw material use through time or between cultures?

The purpose of this final chapter is to do just that. I will propose, in fact, that in all these observations and data we can identify four basic patterns of raw material use, and describe the general characteristics of each. We can go on to examine what each of these patterns looks like in different resource regions and subregions, as the patterns are expressed in different sets of raw materials. In addition, we can overlay this with changes in the circulation of various raw exotic and other nonlocal raw materials, and add some information on associated technologies.

The result is a hypothesis that works as a model of raw material provisioning, use, and circulation over a period of several thousand years, from the earliest evidence for a human presence in the region to the demise of lithic technology with intensive agricultural and industrial settlement in the nineteenth century. The model will be richer in some parts and thinner in others, but in a broad sense it will be comprehensive. That is, it will cover the entire research region and the entire time period when lithic technology is used in that region. In theory, it should encompass any and all regional lithic assemblages. The model will explicitly *not* be comprehensive in accounting for all technological or stylistic factors. Clearly these matters are important, but they are also beyond the scope of the present research.

Importantly, the model is testable. In addition, when combined with the analytical perspective and methods introduced in the previous chapters, it will hopefully provide a productive approach to regional raw material studies, one that will help us to ask useful questions and to communicate effectively on the topic.

Much of the preceding discussion has been framed in terms of the culture-historical framework most commonly used in the region – Paleoindian, Archaic, Woodland, and so on. While there does seem to be some correspondence between raw material use and this framework, we would do well not to assume a rigid correspondence. Indeed I expect that we will, with further research, find that the correspondence is only general, and that instances of raw material use do *not* correspond with the culture-historical framework prove to be especially interesting. Therefore it is best to define (and name) raw material use patterns without reference to Paleoindian, Archaic, and so on.

Instead I propose that we first focus on a particular, intrinsic raw material characteristic as a way to organize our thinking and discussion about raw material use. That characteristic is package size. Although this does not account for some aspects of changing raw material provisioning and use, it does seem to capture an essential element. In addition, since each package of raw material begins the reduction sequence as a core, and since core reduction is a central element of flintknapping, we can combine the ideas of package size and core reduction in the basic definitions of different raw material use patterns. This helps us form the definitions and names for three of the four basic raw material use patterns: Boulder Core, Cobble Core, and Pebble Core. Alternatively, these are referred to as the B pattern, C pattern, and P pattern. Note that these names also imply, if somewhat obliquely, changes in provisioning strategies (from gathering boulders to gathering cobbles to gathering pebbles).

A fourth use pattern is defined along a somewhat different axis, emphasizing provisioning strategy rather than package and core size. This strategy involves getting a certain part of the raw material supply from a source where a particular raw material is concentrated and abundant. This is the Strategic Source pattern – or S pattern. It might be more comfortable to have a greater degree of consistency in how the patterns are named, but this slight discordance in nomenclature seems hard to avoid.

The first part of this chapter is dedicated to reviewing these use patterns region by region. This also includes consideration of the circulation of exotic and other nonlocal raw materials, and some thoughts on technological associations and implications.

The final part of the chapter considers how both models -- resource region and use patterns -- might be used, how they might be improved, and how they might relate to broader issues in our study of prehistory. For example, a consideration of the practical application of utility analysis looks at practical limitations and potential problems, issues of sampling and context, and how localizing the models might improve their performance. A discussion of potential future research issues includes calibration of the models, improving lithic data quality, looking at lithic technology, testing the models, issues of chronology, and the potential geographic extent of application. Finally, some consideration of broader issues touches on use patterns and culture history, forces driving pattern changes, and the effects of factors extrinsic to lithic technology and economy.

LITHIC RAW MATERIAL USE PATTERNS

There appear to be only four basic raw material use patterns, each named for some characteristic that distinguishes it from other patterns. These are the Boulder Core, Cobble Core, Pebble Core and Strategic Source patterns. Each covers multiple resource regions, although it is sometimes possible to find distinctive local variations. The patterns may be variously sequential or contemporaneous. At a fundamental level, each pattern has continuity throughout its duration. That is not to say, however, that a pattern is static. Changes in nonlocal raw material availability or other factors produce changes in the expression of the underlying pattern, a fact that increases the diagnostic utility of the model.

Each of the patterns is discussed below. This includes an examination of which local raw materials are favored and which are ignored, the place of nonlocal raw materials, and the general level of the movement of raw materials. There is also some discussion of what technological or other factors may be driving each raw material use pattern, although this model is more concerned with describing *what* is going on rather than *why* it is happening. The parts of the discussion addressing driving forces for pattern changes should be regarded as speculative, and as suggestions for further research.

It is especially important to remember that a change in raw material use pattern does not imply a complete change in tool types or reduction strategies. In the case of the change from Boulder Core to Cobble Core patterns, for example, it looks like some tool types and reduction strategies were abandoned, while others (end scrapers, for example) continued with little or no change. In contrast, in the case of the change from Cobble Core to Pebble Core patterns there may have been no abandonment of technologies but rather the addition of new reduction strategies and possibly even tool types. The use pattern model speaks primarily to the overall toolstone provisioning strategy, and only secondarily to changes in tool types or reduction strategies.

As you read the following discussion, you might conclude that the perspective is too constrained by the culture-historical system of Paleoindian, Archaic, Woodland and Villager. I believe that there seems to be some correspondence, but I would like to protest that I have not felt completely constrained by that fourfold division. First, an earlier version of the use pattern model proposed seven basic use patterns instead of four. Although the seven patterns did align to some degree with the four basic culture-historical divisions, there was necessarily less precise correspondence. Second, it may be that – at least in some cases – the patterns are not as distinctive as the model may make them sound. There appear to be change within each pattern, and it may be that what the model presents as a change from one pattern to another is actually just an evolution – a gradual transition from one state to another. Imagine, for example, that the C and P patterns are just different parts of one continuum of development, with a gradual expansion of raw material provisioning and no clear boundary between them. If this were to prove true, the correspondence with the cultural-historical stages is less than perceived and therefore not a matter of great concern.

Finally, I do not purposely propose that the use patterns necessarily correspond to the four culture-historical divisions. I suspect there is some correspondence, but sorting that point out is a potentially useful line of future inquiry. We might find good correspondence. We might also find, in contrast, that patterns appear in different regions at different time – and in different culture-historical frameworks. We might even find, as a further example, that the P pattern appears and disappears through time in different culture-historical contexts. At this point, the jury is out.

Boulder Core Pattern

The Boulder Core pattern was associated with the production of large bifaces, including projectile points. Initially these were lanceolate forms, some fluted. Later, in some areas, it may also have been associated with large notched forms. Other associated tool types include prismatic blades, flaked trihedral adzes and axes, and keeled scrapers.

It appears that the driving force for this pattern was selection of raw materials that dependably occurred in large pieces. In our approximate scale of package size, that probably means pieces that were at least the size of large cobbles, and preferably the size of boulders or – better yet – materials that came from outcrops where size was not really a limiting factor. One effect of this is low raw material diversity in Boulder Core assemblages, since relatively few raw materials met that criterion. General flaking quality was also a factor in selection, but definitely a secondary factor. Given a choice of two materials in the appropriate size range, flintknappers preferred the better quality material or simply ignored a marginal quality material. But some of the preferred materials for this pattern are fairly difficult to work –

yet available in the large pieces required.

This interpretation differs from the position of some previous research. Goodyear (1989), for example, maintains that the selection was for fine-grained, high-quality toolstone. He further connects the requirement for such materials to the requirements of an associated curated technology. However, Goodyear does not consider or discuss the possibility that the selection was actually for package size, and that some raw materials chosen because of package size also happened to be fine-grained, good-quality materials. His argument probably does not allow this possibility, since the information he used suggested that the use of the high-quality materials was prevalent "over all of North America where ever Paleoindian assemblages are found" (Goodyear 1989:1). Note, however, that this cannot be the case since there is abundant evidence from sites in the Upper Midwest at least that Paleoindians made good use of lower-quality raw materials. It seems likely that the same could be said for other regions. Thus it may be that we see different selection pressures in different areas, or that Goodyear's approach needs to be widened to see whether package size may be a critical selection element. (In fairness, it should be noted that Goodyear's paper is only nine pages long, and intended as an introduction rather than a fully developed study.)

Note that while relatively few materials dependably occur in large pieces, many raw materials occasionally to rarely occur in large pieces. It seems unlikely that a Boulder Core flintknapper would have rejected a large piece of Red River Chert, for example, just because other pieces of RRC were small. In addition, smaller pieces of toolstone were probably used opportunistically to produce smaller tools – end scrapers, for example. The evidence suggests, however, that this was not a regular practice, and we can hypothesize that it was simply outside the overall strategy of raw material provisioning and tool production. Thus uncharacteristic raw materials *could* find their way into Boulder Core assemblages. They constituted a minor element, however, and do not negate the fundamental characteristics of the pattern.

Large bifaces were not the only distinctive tool type associated with this pattern. Goltz (2001), for example, defined a regional Paleoindian tool type called the Itasca Knife. This is a backed bifacial knife with a ground edge and a notch along one edge. Known specimens measure 10 cm or a little more in length. Evidence like that from the Pelland blade cache (Stoltman 1971) suggests that prismatic blades on the order of 10 cm long were sometimes part of the toolkit (cf. Root 2000). And at least in the northern parts of the region, flaked stone axes and adzes were also important. At the Bradbury Brook site, for example, there were adzes made of Knife Lake Siltstone, the same material used for bifaces and other kinds of tools (Malik and Bakken 1999). Examples occur at many other sites in parts of northern Minnesota, northwestern Ontario and southeastern Manitoba (e.g., Buchner 1979, 1981, 1984; Fox 1975, 1980; Harrison et al. 1995). The production of such tools would also have required relatively large pieces of toolstone. Note that in later use patterns, this technology was moved from the realm of flaked stone technology to ground stone, thereby altering raw material requirements.

The distribution of exotic and other nonlocal raw materials in the Boulder Core pattern was very extensive but very low intensity. In other words, very small amounts of raw material moved a very long distance. It is difficult to document the distance of distribution using the current data set. Many researchers, however, have already noted this in other parts of the continent, and the phenomenon is relatively well documented (see Goodyear 1989). This kind of raw material movement could account for the relatively high number of Paleoindian points made from sometimes distinctive but unidentified materials. For example, in Higginbottom and Shane's (1996; Higginbottom 1996) inventory of fluted points from Minnesota, 3 of 27 (%=14.8) points could not be identified to raw material; "unidentified" was the fourth most common raw material "category." In Florin's (1996) inventory of Late Paleoindian points from the state, the popularity of unidentified increases to third, at 39 of 249 points (%=15.9).

These two Paleoindian point inventories also point to a possible evolution in the expression of the Boulder Core pattern. The raw material inventory for the Early Paleoindian fluted points (Table 4-31) suggests that raw material selection may have been even more restrictive in that period. Note that just three materials (Hixton Quartzite, Cedar Valley Chert, Gunflint Silica) account for over 60 percent of the points. For Late Paleoindian (Table 4-30), it take five materials (Knife Lake Siltstone, Hixton Quartzite, Prairie du Chien Chert, Knife River Flint, Jasper Taconite) to reach or pass 60 percent. Also note the clear changes in the relative importance of individual raw materials. Cedar Valley Chert and Gunflint Silica are very important materials for EPI points, but minor for LPI points. Knife Lake Siltstone and Prairie du Chien Chert are very important materials for LPI points, but do not even appear in the EPI inventory. Only Hixton is relatively important in both cases.

It is hard to know if this is a real change or, if it is, what the reasons might be. The sizes of the inventories are very different (EPI=27, LPI=245), and essentially-random sampling effects could be skewing the smaller sample. But if the shift is real, what could account for it? We might consider whether fluting imposed additional limitations on raw selection. Making large bifaces required large pieces of toolstone, and maybe fluting also required that the toolstone was high quality. However, Hixton is reportedly not especially easy to flake – at least most pieces. Alternatively, it might be that some toolstone sources used by Late Paleoindian populations were just not accessible to Early Paleoindian populations. Some sources could have been blocked or even covered by glacial ice, proglacial lakes, or related landscape conditions.

We should also note one other caveat here. Point data is a legitimate source of information, and especially useful in the Paleoindian period when point styles are more distinctive and diagnostic. Point data, however, are not directly comparable to data from full lithic assemblages. These two data sets (points vs. full assemblages) give us two different perspectives on the associated lithic economies.

Boulder Core Pattern in the South Agassiz Resource Region

In the South Agassiz Region, Swan River Chert and Lake of the Woods Rhyolite were the preferred local materials for the Boulder Core pattern (Tables 4-17, 4-19, 4-20, 4-21). Lake of the Woods Chert was also used, although its use seems to be focused in the Lake of the Woods area. This may be because larger pieces were available from bedrock in that vicinity, whereas the raw material stock in glacial till probably consisted of smaller pieces. Red River Chert occurs, but only in small amounts. The favored nonlocal material was Knife River Flint, with smaller amounts of Hixton or other nonlocal materials. Tongue River Silica, quartz and the miscellaneous pebble-sized raw materials were all but ignored and seldom seen in Boulder Core pattern assemblages.

Boulder Core Pattern in the West Superior Resource Region

In the West Superior Region, a number of materials were important in the Boulder Core pattern (Tables 4-17, 4-22, 4-23). In the vicinity of Thunder Bay and the far northeastern tip of Minnesota, Jasper Taconite was the most important material. In much the same region, Gunflint Silica was also important. Farther to the west and southwest, Knife Lake Siltstone was favored. This included both the high-quality, "weapons-grade" KLS (Nelson 2003:46) from bedrock sources along the Minnesota-Ontario border, and the often poorer-quality KLS found in till sources to the southwest. The favored nonlocal material was Hixton Quartzite, with a minor presence of Knife River Flint and Prairie du Chien Chert (the latter in the Quartz Subregion). Quartz, Hudson Bay Lowland Chert and Lake Superior Agate were largely ignored (although, surprisingly, Higginbottom and Shane [1996; Higginbottom 1996] document a fluted point made of Lake Superior Agate).

Boulder Core Pattern in the Pipestone Resource Region

In the Pipestone Region, our meager knowledge of the raw material resource base makes it difficult to define the Boulder Core pattern in any detail. One clue comes from the Cherokee site (Anderson 1980; Appendix 2: 13CK405), where Tongue River Silica constitutes 19.5 percent of the Late Paleoindian lithic assemblage. In the other regions under consideration, TRS was ignored during the Late Paleoindian period and in the Boulder Core pattern. This suggests two possible conclusions for Cherokee and the Pipestone Region: 1) the TRS found in the old till exposed in this region was larger in size and therefore suitable, despite its poor quality, for making large bifaces; or 2) the flintknappers in this region had sorely limited lithic resources, and were obliged to make use of poor quality stone that other populations could afford to ignore. Both of these points are conjectural, however, and require further investigation. From the Cherokee site we also know that one or more Fusilinid Group cherts were a favored nonlocal material.

Boulder Core Pattern in the Hollandale Resource Region

In the Minnesota portion of the Hollandale Region, Prairie du Chien Chert was the single most important material for the Boulder Core pattern, although Galena Chert was important in the eastern part of the region (Tables 4-17, 4-18). Cedar Valley and Grand Meadow cherts were also used, but to a more limited degree. The favored nonlocal material was Hixton Quartzite, with a minor presence of Burlington, Maynes Creek, Moline and other cherts originating from the south. Quartz and Shell Rock Chert were ignored. Tongue River Silica was also ignored, although this is more or less the case for all use patterns in the Hollandale Region.

Summary

In summary, the Boulder Core pattern is characterized by intensive focus on a narrow range of raw materials that could be dependably found in large pieces. The focus may be even narrower in the early expressions of this pattern, perhaps focused on the better quality materials in the required size range. Other raw materials were largely or completely ignored, and raw material diversity was low. Raw materials were circulated over very long distances but in very small amounts.

Cobble Core Pattern

The Cobble Core pattern contrasts strongly with the Boulder Core pattern that preceded it. Whereas the Boulder Core pattern was distinguished by large lanceolate bifaces, the Cobble Core pattern began with smaller notched points and even unnotched triangular forms. This shift had a clear impact on habits of raw material provisioning. More specifically, raw material resource selection broadened. Materials that were previously ignored were now used, since the restrictions on size of toolstone stock were considerably eased. Pieces of toolstone that were too small to use for making large bifaces or flaked stone adzes were perfectly adequate for making the new, smaller kinds of points. As a result, the overall raw material diversity of C-pattern assemblages increased, although some raw materials were still ignored at this point. The resulting assemblages can look quite different from one region to another, however, and the changes are more obvious in some regions than in others.

At the beginning of the Cobble Core pattern, the circulation of nonlocal raw materials appears to have been very limited in both extent and intensity. If anything, there was a decrease from the Boulder Core pattern, at least in extent.[1] Some of the data give the impression of a sort of collapse of raw material circulation. This circulation did build up over time, with different timing in different regions and with different raw materials. By the later parts of the Cobble Core pattern, in fact, exotic raw materials dominated lithic assemblages in some parts of the region.

The change from Boulder Core to Cobble Core patterns at least appears to be fairly abrupt in the western and northern parts of our study region. This is not necessarily the case in the southeastern parts of the study area, however. In these regions, point styles like Hardin Barbed seem to have developed directly out of antecedent Paleoindian forms

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[1] Note, however, that if we posit first-hand provisioning by wide-ranging, highly-mobile groups as part of the Boulder Core pattern, this "collapse" of raw material circulation could simply reflect a decrease in mobility; perhaps exchange networks did not exist in any familiar sense, and had not yet developed (cf. Andrefsky 1983, 1991; Bamforth 1986, 1990; Kelly 1988; Morrow and Jefferies 1989; Parry and Kelly 1987; Shackley 1990; Torrence 1983, 1989).

(Scottsbluff in this case; cf. Luchterhand 1970; Munson 1967). Although the new forms were notched, they were still large – often comparable in size to Paleoindian lanceolate points. It is not clear whether the notched points also served as biface cores, or what kind of changes – if any – happened with raw material provisioning. It may be, although this is not clear, that the Boulder Core pattern continued to the east. No doubt the data exist to answer (or at least explore) these questions, but such data were not gathered for the current research since most would be found in regions beyond the study area.

Goodyear (1989:7) offers an observation on the demise of the B pattern and appearance of the C pattern and of its possible geographic extent, noting that "The Paleoindian pattern contrasts markedly with the following Archaic age raw material patterns which reflect increasing reliance on local and more coarse grained raw materials." It is interesting that this observation speaks of a good part of North America.

Cobble Core Pattern in the South Agassiz Resource Region

In the South Agassiz Region, Swan River Chert continued to dominate lithic assemblages but usually not as completely as it did with the Boulder Core pattern (Table 4-16, 4-19, 4-20, 4-21). This is because other raw material like Red River Chert and Tongue River Silica now constituted a greater part of lithic assemblages. Nonlocal materials were initially rare, with one important caveat. It seems that Knife River Flint was present in the Red River Valley (Tamarack and Upper Red subregions) in essentially all periods and patterns. The amount was still reduced, however, in the initial phases of the Cobble Core pattern. It is not clear how far east Knife River distribution extended at this time, but the fall off appears to be quick and KRF may not have extended far beyond the Agassiz beach ridges. Conversely, the intensity of KRF use rose relatively quickly to the west of the Red River (with greater proximity to the KRF primary and secondary source area). Besides KRF in the two northern subregions, occasional pieces of Burlington Chert occur at initial Cobble Core sites in the Shetek Subregion to the south. In any case, the amounts of KRF rose with time in the Cobble Core pattern. The rate of increase is not yet clear. Initially, however, it appears that the increase was relatively slow through most of the duration of the pattern, with a relatively sudden and clearly large increase some time shortly before 3,000 BP. After this point, KRF constituted the major raw material at some sites along the Red River.

The role of Tongue River Silica requires some additional discussion. TRS should be essentially absent in the Tamarack Subregion and in the Agassiz basin to the west, available in moderate abundance and as smaller pieces in the Des Moines lobe till in the central parts of the region, and much more abundant and as larger pieces in the Wadena lobe till on the western edge of the subregion. Thus in different parts of the subregion, TRS was probably used somewhat differently because of the variations in package size and relative abundance. In some early Cobble Core assemblages, TRS occurs at high to very high levels. In fact, the highest levels of TRS occurrence may be in assemblages from early C-pattern sites, at least in the eastern reaches of the Upper Red Subregion. This should not often be the case with assemblages from the western or central parts of the subregion.

Cobble Core Pattern in the West Superior Resource Region

For the West Superior Region, we can make a few general observations that seem to pertain to most of the region. The use of Knife Lake Siltstone decreased dramatically with the advent of the Cobble Core pattern (Tables 4-16, 4-22, 4-23). The decrease was, in fact, around an order of magnitude. Quartz became an important material. This may mostly reflect use of the Fat Rock Quartz sources near Little Falls, but this is not clear since Fat Rock is not separated from other quartz in the data. Alternatively it could reflect use of quartz cobbles from glacial sediments, although this seems less likely. As expected based on the use pattern model, a wider range of materials came into use; the materials varied in different parts of the region. Exotics and other nonlocal materials were present in very small amounts or were absent, also as expected. Beyond such general observation, we need to examine the two subregions separately since different suites of raw material predominate and the expression of the use pattern can look very different.

Before we examine the subregions, however, it may be helpful to reconsider the issue of quartz in the West Superior Region. Recent research, discussed in Chapter 3, allows us to now distinguish two separate categories of quartz with different flaking characteristics and sources. Fat Rock Quartz has a metamorphic structure and is relatively flakeable. It comes from sources along the Mississippi in and near Little Falls, Morrison County. Other quartz is for the most part marginally flakeable. It is widely available, especially from glacial sediments but probably also from bedrock sources at some locations. Since this distinction was only recently recognized, the two kinds of quartz are not distinguished in the data and there is presently no way to estimate which sources contributed which proportions or how these proportions changed geographically or chronologically. This is a major handicap in analysis of raw material use patterns in the West Superior Region, and especially in the Quartz

Subregion. The following discussion of quartz use must therefore resort to evaluating different options in use patterning based on provisioning from one or the other source.

In the Arrowhead Subregion, KLS use fell by an order of magnitude. Quartz use increased by nearly an order of magnitude to a level of roughly 20 to 25 percent. This might reflect the initial use of the Fat Rock Quartz source to the southwest, or the initial use of local quartz derived mostly from glacial sediments. The use pattern model suggests that the latter option is more likely, since it purports strongly local provisioning at the beginning of the Cobble Core pattern. The ordinary quartz from glacial sediments is local, while Fat Rock Quartz is not. The model also suggests that the local quartz was reliably available in cobble sized pieces, in contrast to some other parts of the state where it was primarily available as pebbles. These hypotheses must be tested, however. Animikie Group silicates remained in use. It looks like the importance of Gunflint Silica rose, which might reflect availability of this material from glacial sediments as pieces of roughly cobble size. Also, the numbers for undifferentiated Animikie Group silicates rise in the data I am using, possibly suggesting that the Cobble Core flintknappers were less particular in their selection of the Animikie Group silicates, or alternatively that they were using local cobbles that were just more diverse in their characteristics. Hinshelwood (1994:48) notes that use of Kakabeka Chert, minor in the previous pattern, increased in the Archaic (i.e., the advent of the Cobble Core pattern). It looks like the use of HBLC rose slightly but still remained quite limited. Hinshelwood (1994:48) also notes this appearance of HBLC, tying it to the beginning of the Archaic tradition (which here would be equivalent with the advent of the Cobble Core pattern). Based on the assumptions of the model, this could suggest that local HBLC was available mostly as pebbles. The cobble-sized HBLC available was essentially a nonlocal resource, and thus beyond reach in an era of limited raw material circulation. Use of Lake Superior Agate was very limited, and does not appear to have increased over the duration of the pattern.

It looks like circulation of exotics and other nonlocal materials increased slightly over the duration of the Cobble Core pattern, although the levels were never high. The available data suggest, rather surprisingly, that Knife River Flint may have been relatively most abundant. Note, however, that this is based on limited data; examination of a larger data set might prove these tentative interpretations wrong. Materials from neighboring regions appeared in very small amount, including such materials as Swan River Chert, Tongue River Silica and Prairie du Chien Chert. By the end of the Cobble Core pattern, we also find increased use of HBLC.

In the Quartz Subregion, the use of KLS fell by an order of magnitude while quartz use increased by an order of magnitude. But in this subregion, the dual-quartz quandary is even more of a problem since the overall level of quartz use is considerably higher. Here, however, both Fat Rock Quartz and till-quartz could be considered local resources over at least part of the subregion. The use pattern model may favor the predominance of Fat Rock over other quartz in the Cobble Core pattern, if Fat Rock is consistently available as cobble size pieces (which seems to be the case) while other quartz is not (which is less clear), or alternatively if both are available as cobble size pieces but Fat Rock is simply better suited to the purposes of the C-pattern flintknappers. Conceivably it could even be that Fat Rock accounts for the quartz increase in the western part of the subregion while other quartz accounts for the increase in the eastern part. At present this is all largely speculation, however, until we begin to accumulate lithic data that distinguish the two materials.

In contrast to the Arrowhead Subregion, the use of Animikie Group silicates (whether specifically identified or not) remained quite limited, as did the use of HBLC. Use of Lake Superior Agate was very limited, and does not appear to have increased over the duration of the pattern.

Exotics and nonlocal raw materials were present at a low level, and exotics may have increased somewhat over the duration of the Cobble Core pattern. For exotics, both Hixton Quartzite and Knife River Flint occurred in small, roughly equal amounts. Initially it looks as though they were present only in small traces at the start of the Cobble Core pattern, then increased slightly in abundance over the duration of the pattern. Nonlocal materials, as in the Arrowhead Subregion, included Swan River Chert, Tongue River Silica and Prairie du Chien Chert, and to a lesser degree may have included traces of other materials from neighboring resource regions. Note, however, that different raw materials may have followed different timelines in terms of waxing and waning circulation.

Cobble Core Pattern in the Pipestone Resource Region

In the Pipestone Region, our meager knowledge of the raw material resource base also makes it difficult to describe local implementation of the Cobble Core pattern in any detail. Our best clue again comes from the Cherokee site (Anderson 1980; Appendix 2: 13CK405), where Tongue River Silica rises from 19.5 percent of the Late Paleoindian (B-pattern) lithic assemblage to 89.7 percent of the Early Archaic (C-pattern) assemblage. This could suggest that TRS was the most common local raw material, but that a good percentage of the available pieces were too small to be useful in the previous Boulder Core pattern;

alternatively, TRS flaking quality might simply be too poor to support a Boulder Core technology, obliging the populations to look elsewhere for raw materials. (Closer analysis is hampered since most of the Cherokee data is not reported using current raw material types.) In any case, with the technological shift that came with the Cobble Core pattern, the useable supply of TRS greatly increased. Fusilinid Group cherts, which come from some distance and constituted a few percent of the Boulder Core assemblage, are nearly absent in the Cobble Core assemblage.

Cobble Core Pattern in the Hollandale Resource Region

In the Hollandale Region (Tables 4-16, 4-18), the characteristics of the Cobble Core pattern are not entirely clear. In part this is because the Hollandale Region includes primary-source "hot spots" for materials like Prairie du Chien Chert. This happens in cases where a primary source presented an abundant supply of a single raw material, and that raw material dominated assemblages near the source and sometimes for miles around. In these cases assemblages of all patterns or periods can look very similar, and the shift from B pattern to C pattern might be difficult to detect.[2]

In other cases, however, the shift might be much plainer. In the "driftless zone" it may be hard to separate B from C assemblages, except possibly for the addition of GMC or Shell Rock Chert (the latter minor), or the presence of multiple B-pattern raw materials. How well this shows up will, however, probably depend on proximity to a primary raw material source and any associated "hot spot." In areas with either Des Moines lobe or old till (and possibly the Superior tills exposed in the northern reaches of the Hollandale Region), however, the situation should hopefully be different. In these areas C-pattern assemblages could include some, albeit probably limited, materials from the till. This should have left a fairly plain signature in many cases. However, as in the "driftless zone," proximity to a to a primary raw material source and any associated "hot spot" would also tend to suppress use of the till based materials, although the overprint zone might be smaller than in the "driftless zone."

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[2] This also suggests a venue for future research, however. It might be that the "overprint" zone around a primary source changes size or configuration through time. If that were the case, examining the raw material composition of assemblages within a few miles of primary sources could provide useful information on the inner dynamics of use patterns.

Summary

In summary, the Cobble Core pattern is characterized by a broader focus on raw materials available as cobble-sized and larger pieces. Assemblage diversity is therefore usually greater than in the P-pattern assemblages. Initially at least provisioning was intensely local, and the circulation of both exotic and nonlocal raw material appears to have been very limited both in extent and intensity. In fact, some evidence suggests a collapse of raw material circulation. It appears that the extent and intensity of raw material circulation rebuilt through time in the Cobble Core pattern, but note that each raw material may have a different history of how quickly their circulation rebuilt or peaked.

Pebble Core Pattern

There is less of a contrast between the Pebble Core and Cobble Core patterns than between the Boulder Core and Cobble Core patterns. It looks like the Boulder-Cobble transition was marked by replacement of reduction strategies and tool types, but it seems that the Cobble-Pebble transition was marked not by replacement but by the addition of reduction strategies to the previous technological repertoire (or perhaps just a change in emphasis). It seems that the Pebble Core pattern was associated with bipolar reduction of pebbles. Details of the reduction sequence, and even the desired products, are not clear.

It is clear, however, that this technological shift expanded the resource base. Pebbles that had previously been ignored, often pebbles of good quality raw material, now became a useable resource. The use of larger pieces was not abandoned, of course, just supplemented. The reasons for this have been examined and debated in other regions. Some researchers maintain that is related to raw material stress or constraints experienced by populations who were increasingly sedentary or restricted to smaller territories (e.g., Kelly 1988, 1992; Parry and Kelly 1987; cf. Moffat 1996). This is a feasible explanation that needs to be considered, but it should not be considered the only feasible explanation for adopting a Pebble Core pattern.

Use of this strategy or something similar may not be exclusively confined to the time period generally covered by the Pebble Core pattern. It is not hard to imagine, for example, that this strategy would be a good recourse in a tight situation. Given an immediate need for at least rudimentary stone tools, and no available lithic stock except a few pebbles, bipolar reduction would effectively be a "Plan B" or "emergency" strategy. We might expect, however, that this was the occasional exception and would not leave as strong an imprint on lithic raw material profiles as we see in Pebble Core pattern assemblages. This possibility, however, remains to be investigated.

At this point, it is still not clear exactly when the shift to a Pebble Core pattern happened, or even whether the shift occurred at different times with different cultural traditions or in different places. It may have coincided with the beginning of the Woodland period, but there is no compelling reason that it must. It may have, for example, coincided with the beginning of the Late Woodland – or with some other point in time. There are two main reasons for the difficulty in figuring out when this change occurred. First, the initial transition to a Woodland way of life is not well understood in the state. At this point it is clear that ceramic cultures are present before the Middle Woodland. The chronology of these initial ceramic cultures, however, remains controversial (e.g., Hohman-Caine and Goltz 1995a), and it is still not clear to what degree they practiced a Woodland way of life (cf. Gibbon 1986). This uncertainty over the initial Woodland also means that it can be unclear which sites should be attributed to this period.

Second, the period when the initial Woodland traits showed up in the region is bracketed by the Late Archaic and Middle Woodland. These were the two high points in the use and distribution of Knife River Flint in the greater region, and the abundance of KRF sometimes overprints and obscures underlying use patterns. It is not clear at this point whether the abundant supply of KRF continued from the Late Archaic and right into the Middle Woodland, or whether some intervening decrease in the supply of KRF would allow detection of a new pattern. This question should not be hard to resolve as we better understand the advent of the Woodland, and also as more sites are discovered that apply to the problem.

The distribution of exotics and other nonlocal raw materials in the Pebble Core pattern can be characterized as having an increased extent but low intensity. In addition, raw material circulation included both exotics and a large number of other nonlocal raw materials. In other words, P-pattern assemblages in general will have very small amounts of many nonlocal raw materials; lots of raw materials were moving farther in small amounts. This helped contribute to high raw material diversity in Pebble Core assemblages, which was already increased because of the use of an increased range of local raw materials.

Pebble Core Pattern in the South Agassiz Resource Region

In the South Agassiz Region as a whole, the level of quartz use rose and Swan River Chert became less dominant (Tables 4-15, 4-19, 4-20, 4-21). Beyond that, the characteristics of the Pebble Core pattern vary somewhat from one subregion to another.

In the Tamarack Subregion, the level of quartz use rose from negligible to a few percent. Raw material diversity rose, in part because of an increase in nonlocal materials like Animikie Group silicates and Tongue River Silica; very little TRS was present in assemblages associated with other patterns. Red River Chert use also increased, although this statement requires some elaboration. It seems that RRC occurs in this subregion as a mix of cobbles (less common) and pebbles (abundant). The use pattern model would thus anticipate some use of RRC in the Cobble Core pattern and a sharp rise in the importance of RRC in the Pebble Core pattern.

Given the general association of Cobble Core with Archaic and Pebble Core with some part of the Woodland, we would expect to see higher levels of RRC use at some point in the Woodland period. Instead, we see that some Archaic sites in the subregion have levels of RRC equaling or exceeding the levels of Swan River Chert. This is certainly associated to some degree with bipolar pebble reduction. At some sites, however, much of the Red River Chert takes the form of burned, fragmented (one might say smashed) pebbles. This is hard to explain, and it is not even clear to what degree this is associated with deliberate lithic reduction of any sort, bipolar or otherwise.

Gonsior and Radford (2005:41-42) propose that this sort of phenomenon (albeit in ceramic-period assemblages) is a localized pattern in the Red Lake basin, where toolstone was hard to come by and occurred mostly as pebbles. This is a reasonable proposal, and one that deserves closer attention. The same or similar phenomenon is seen, however, at sites beyond the Red Lake basin (e.g., Murray et al. 1991). In the latter example, in fact, intensive RRC utilization is seen in aceramic, presumably Archaic assemblages.

This raises interesting problems and questions. What, for example, was the place of burned and smashed Red River Chert pebbles in terms of lithic technologies and raw material economies? Should they even be inventoried as part of the normal lithic assemblage? And what about the appearance of what looks like the Pebble Core pattern in Archaic sites? Can this be seen as the potential beginning of P-pattern practices, or is it better understood as a limited, localized response? If the latter is the case, what does that tell us about the relationship between the C and P patterns? Perhaps the bipolar pebble reduction strategy was part of the C-pattern repertoire, a sort of "Plan B" that was only used in cases of serious raw material stress. In that case the shift from the C pattern to the P pattern was more a change of emphasis, marking the time when bipolar pebble reduction became common, clearly visible in the archaeological record, and began to reorient the overall provisioning strategy. That would mean that some assemblages that should look like the C pattern would instead look like the P pattern, a factor that adds interest to raw material analysis but also complicates the use of the raw material use model as a diagnostic tool. It could also mean that there is no clear boundary between the C and P patterns, but rather a gradual change in relative importance of different reduction and provisioning strategies. In any case, this should prove to be an interesting and potentially very fruitful avenue of research.

In the Upper Red Subregion, this "Red River pebble issue" does not seem to be a factor. Instead the levels of RRC were very low in B-pattern assemblages, relatively low in C-pattern assemblages, and noticeably higher in P-pattern assemblages. The level of quartz use also increases in P-pattern sites. An apparent rise in the level of generically identified materials might relate to increased use of the pebble-sized stock of the Western River Gravels Group. The levels of TRS use remained about steady.

In the Shetek Subregion, there was a substantial increase in quartz use. Somewhat surprisingly, there does not appear to have been an increase in Red River Chert use. The relative importance of Swan River Chert decreased. In contrast to the Upper Red Subregion, there did not seem to be an increase in the level of generically-identified materials; this could suggest a lesser role for the Western River Gravels Group materials and similar resources. On average, P-pattern sites contain more Prairie du Chien Chert, but this might vary so much from site to site – especially along an east-west gradient – that it may not be useful as a diagnostic indicator.

Pebble Core Pattern in the West Superior Resource Region

In the West Superior Region (Table 4-15), it is difficult to discuss region-wide characteristics of the Pebble Core pattern. Instead we will look at it separately for the two subregions.

In the Arrowhead Subregion (Table 4-22), the Pebble Core pattern was apparently associated with a sharp increase in the use of Hudson Bay Lowland Chert. This change may be more evident in some parts of the Arrowhead Subregion than in others. Somewhat surprisingly, there does not seem to have been a general increase in the use of Lake Superior Agate, although it might be seen at some individual sites. The use of quartz increased slightly. Since the available data do not distinguish between Fat Rock Quartz and other quartz, it is hard to interpret this increase. It might represent the addition of bipolar pebble-core reduction to the previous use of Fat Rock Quartz in bifacial reduction. There may have been a rise in the occurrence of Knife River Flint, although it is hard to be sure about this. The data suggest the misidentification of KRF in some assemblages in the subregion.

In the Quartz Subregion (Table 4-23), the Pebble Core pattern was apparently associated with the use of Lake Superior Agate. This is not to say that LSA never occurred in assemblages associated with other use patterns, but it does seem to have a much stronger association with the Pebble Core pattern. In addition, it seems there were changes in the prevalence of quartz use. Unfortunately there does not seem to be a consistent pattern of increase, decrease or stability in quartz use, and it will take more work to understand the apparent fluctuations. It seems that HBLC is *more* common in Pebble Core assemblages, although it does occur in earlier assemblages and is never particularly common. It appears there was an increase in the presence of Swan River Chert, which would represent increased movement of raw materials from the west. And in one particularly interesting change, obsidian appeared in some Pebble Core assemblages. Although it is difficult to completely rule out the presence of obsidian in other patterns, its occurrence does seem to be a potentially good indication of a P-pattern affiliation.

Pebble Core Pattern in the Pipestone Resource Region

In the Pipestone Region, we are not yet able to adequately evaluate raw material use associated with the Pebble Core pattern. It may be that Gulseth Silica usually occurs as pebbles, although this is speculative. If this is the case, we could expect to see increased percentages of Gulseth in P-pattern assemblages. A colorless chalcedony, not yet specifically identified or named, has also recently been seen in a small raw material sample from the Pipestone region. The available raw material samples are all pebbles, suggesting that this may also be a material that would appear in P-pattern assemblages; alternatively, further survey could establish that this material is also available as cobble-size pieces, which would change its place in a utility analysis. Petrographic analysis establishes that this material is actually a chalcedony in the petrographic (rather than generally descriptive) sense (Michlovic and Saini-Eidukat, personal communication 3 November 2008). This could be a material that has been described and identified in other parts of North Dakota or South Dakota, although so far such an association has not been found.

Pebble Core Pattern in the Hollandale Resource Region

In the Hollandale Region (Tables 4-15, 4-18), it can be a bit more difficult to recognize

Pebble Core assemblages. In part this is because of differences in the resource base from west to east, and in part because of the sometimes overwhelming imprint of primary raw material sources. If we account for these factors, however, the expected patterns do emerge. We can see, for example, the predicted rise in diversity. Whereas B- or C-pattern assemblages might emphasize one regional raw material more heavily, a P-pattern assemblage is more likely to include multiple regional materials. In the areas mantled by Des Moines or pre-Late Wisconsin till, there was increased use of quartz, Tongue River Silica and Swan River Chert, although this fades as you move east across the Hollandale Region. In addition, the amounts of these materials were small compared to their level of use in some other resource regions. There also appears to have been a slight increase in the amount of Knife River Flint, although that is a tenuous suggestion. KRF was never common in most of the region, and it can be tricky to interpret small fluctuations in small amounts. That said, it does seem possible that KRF was minimally present in the C pattern and possibly twice as abundant in the P pattern. This could vary more by site than by pattern, however, limiting KRF occurrence as a diagnostic tool.

Summary

In summary, the Pebble Core pattern is characterized by use of an expanded range of raw materials. Specifically this expansion focuses on the use of small, pebble-size pieces. For some materials this means intensified use; where occasional cobbles may have been used before, abundant pebbles now came into use. Red River Chert provides a good example of this. But perhaps more useful from a diagnostic perspective is the use of raw materials that only occur in small pieces, materials that would not previously have been present in B- or C-pattern assemblages. The exact materials vary by region, but include such examples as Lake Superior Agate, Western River Gravel Group materials, and quartz in many areas. In addition, there seems to have been a relatively extensive but low intensity movement of many different raw materials between regions. Combined, these two contributing factors lead to higher diversity for P-pattern assemblages than is usually seen in B- or C-pattern assemblages.

Strategic Source Pattern

The Strategic Source pattern differs from the other patterns not so much in terms of raw materials, but in terms of raw material sources. The other patterns were defined largely in terms of intrinsic raw material characteristics, whereas the Strategic Source pattern is defined more in terms of raw material sources and their characteristics. Of the four proposed patterns, this is the most ambiguous and least understood. The Village Culture data do, however, provide clues that allow us to at least sketch out the general features of a Strategic Source pattern.

It seems that most toolstone provisioning in the Strategic Source pattern resembles provisioning in the other patterns, in that it was generally local and included a variety of raw materials (Tables 4-24, 4-18, 4-19, 4-21). It was broader than in B-pattern assemblages, however, and probably narrower than in P-pattern assemblages in that there seems to have been less use of pebble stock. Thus at a underlying level, S-pattern provisioning probably more closely resembled C-pattern provisioning. There is an important difference, however. A significant proportion of S-pattern toolstone came from what we can call a strategic source. It is not yet clear what the proportion would be, although it might be on the order of plus-or-minus 20 percent.

As discussed in Chapter 4, the strategic sources seem to be locations where a particular raw material was available in substantial quantities; potential examples include Silver Mound (Hixton Quartzite), the Grand Meadow Chert quarries, and the Knife River Flint quarries. Proximity to the source did not seem to be a critical factor, as closer potential sources were apparently ignored in favor of more distant sources. There are hints that multiple related or allied populations would depend on the same source, raising the intriguing possibility that a particular raw material played an important role in some larger social, cultural or economic system. And, as Ahler (1977) and Johnson (1984) reminds us, a population could switch as needed or desired from one source to another. This fact could add diagnostic value to the use pattern model. In much the same way that we can distinguish broad time periods within the C pattern by evaluating relative levels of KRF, we should also be able to chronologically orient ourselves more specifically within the S pattern by looking at changes from one Strategic Source to another.

Note that in contrast with other pattern transitions, the change to Strategic Source provisioning does not *require* any change in the kinds of tools that are produced or in reduction strategies. It is simply a change in acquisition strategies. On the other hand, the change to Strategic Source provisioning does not *preclude* changes in the accompanying technology.

The overall distribution of exotic and other nonlocal raw materials in the Strategic Source pattern is not quite clear, but we can make a few preliminary observations. It is, however, an important topic since some of the strategic-source raw materials were exotic or nonlocal. These are discussed section by section below.

Strategic Source Pattern in the South Agassiz Resource Region

In much of the South Agassiz Region, village cultures were absent or minimally represented. The exceptions would be in western parts of the region that fall in North Dakota and South Dakota, and the Shetek Subregion. It seems that an important Strategic Source material for sites in the western part of the region may have been Knife River Flint, while in the Shetek Subregion it may have been Grand Meadow Chert (Tables 4-24, 4-19, 4-21). This is still difficult to be certain about, however, pending examination of additional and data better.

Strategic Source Pattern in the West Superior Resource Region

In the West Superior Region, the Mississippian, Oneota and Plains Village cultures were largely absent, except for some limited influence on Woodland populations. Thus the Strategic Source pattern is not really relevant in this region.

Strategic Source Pattern in the Pipestone Resource Region

In the Pipestone Region, we are again handicapped by the lack of good information on the resource base of the region. Plains Village and Oneota sites would clearly be a factor in the region. Based on reports for surrounding regions, Strategic Source populations in the Pipestone Region might have relied on raw material supplies towards the Black Hills (cf. Johnson 1984) or other parts of South Dakota (Morrow 1994:128), conceivably central to southwestern Iowa, or on Prairie du Chien Chert from the east. In addition, of course, there would also have been substantial use of local materials and more limited use of various nonlocal materials from neighboring regions. Beyond such general speculation, however, there is presently nothing to report on the nature of Strategic Source assemblages in the Pipestone Resource Region.

Strategic Source Pattern in the Hollandale Resource Region

In the Hollandale Region, Prairie du Chien Chert continued to serve as a fundamental raw material, probably because of its relative abundance and widespread availability (Tables 4-24, 4-18). Something similar may be true of Galena Chert in the eastern parts of the region, although this is not entirely clear. It seems that Grand Meadow Chert served as a strategic-source material, important in a few assemblages but minor in most. The role of Cedar Valley Chert is not clear, at least based on the available data.

Hixton Group quartzites, earlier present in minor amounts, reached a peak in S-pattern assemblages. They were still a minor resource in the western parts of the region, but contributed a significant percentage to some eastern assemblages. This suggests that the Hixton Group quartzites were strategic-source materials. If this is the case, they should be common at some sites and almost absent at others. It is not clear whether the quartzite cam from multiple sites in western Wisconsin, or just from Silver Mound. The latter seems to better fit the idea of a strategic source providing a focused and abundant supply. This question should yield to closer research. Note that this is a case where identification of specific raw materials, not just raw material group, would be especially useful.

There is some suggestion that Burlington Chert may also have been a strategic-source material, at least in parts of Iowa. In Minnesota, any patterning in the presence of Burlington Chert needs to be examined more closely. Preliminary observations suggest that it seems to increase slightly in the eastern parts of the region, but decreases in a corresponding amount in the western part of the region.

While KRF is present in trace amounts in C-pattern assemblages and in minor amounts in P-pattern assemblages, it seems to be absent from S-pattern assemblages. At this point it does not look like other extraregional raw materials play a significant role at S-pattern sites.

Summary

In summary, the S pattern is characterized by local provisioning perhaps resembling C-pattern provisioning, but supplemented by significant amounts of a material from a strategic source. Such sources are characterized by relatively dense concentrations and large quantities of toolstone in a restricted area, and associated with a primary context. A given source was apparently shared by a group of related or allied populations, and sources could and did change from time to time. It is not clear at this point whether this kind of provisioning strategy was motivated by social, cultural, economic or other factors. It is also not clear whether strategic-source provisioning primarily involved first-hand or second-hand procurement.

As noted, strategic-source provisioning did not preclude provisioning from other kinds of sources as well. In glaciated areas, for example, there was still some provisioning from the more dispersed, lower-density glacial sources. Trade outside of strategic-source provisioning also played some role, although this seemed to be diminished in importance compared to some other patterns. In addition, the use of pebble-core materials seemed to decline considerably.

PRACTICAL APPLICATION OF UTILITY ANALYSIS

The preceding text proposes a way of looking at lithic raw materials in our region, with a perspective that is somewhat different than previous approaches. It also lays out a particular perspective on what happened historically in the region. That discussion has involved immersing ourselves in a great deal of detail. Now, however, it is time to step back and take a look at some broader issues. These can be loosely organized under the topics of practical application, research issues, and broader contexts.

Practical Limitations and Potential Problems

We already know that there are a few situations where the use pattern model and utility analysis do not work well. The first is near a primary raw material source, where assemblages are usually composed of little except the raw material from that source. We can explain such "hot spots" in terms of a couple of factors. First, in most cases we could expect that there was essentially only one raw material available at that source. Thus the flintknappers were not choosing between different raw materials with different characteristics – the kinds of choices that best reveal the underlying use pattern. Choice at such a site instead focused on factors like sorting workable from badly flawed pieces of stone, or finding pieces of the desired package size. These kinds of choices are difficult to see using raw material analysis (although they might be discernable using technological analyses). Second, sites at primary raw material sources might reflect a very limited range of activities rather than the broader range of activities represented at habitations and many other kinds of sites. More specifically, of course, we could expect that activity is tightly focused on procuring the specific raw material. Together such factors combine to produce assemblages that are monolithic in terms of raw material composition.

This does introduce a set of interesting research questions, however. For example, how far does this single-material dominance extend outward from primary sources? Does this extent change through time? Can we determine a fall-off rate? Finding such a curve could help us control for this factor and thus have a better chance of discerning the underlying use pattern. Could knowledge of such fall-off rates help us determine anything about the extent of territories or seasonal rounds? If we could tease such information from the lithic record, maybe we could also begin to look on how this changed through time.

The use pattern model and analysis also does not work well with some very short-duration, single-use sites. In some cases such assemblages did capture a broad sample of raw material use, broad enough to reveal the associated use pattern. In other cases, however, the assemblages captured a very narrow sample, making it difficult to associate the assemblage with any particular pattern. The Basswood Shores site (Appendix 2: 21DL90; Justin and Schuster 1994) provides an example. This site yielded the remains of two Sandy Lake ceramic vessels and a lithic assemblage composed almost entirely of Maynes Creek Chert. This is especially interesting given that Maynes Creek Chert comes from relatively distant sources in Iowa (Morrow 1984a, 1994), and that this assemblage along represents 96.7 percent of all the Maynes Creek Chert in my Minnesota lithic data. In this case, the site has apparently not only captured a very narrow part of the raw material spectrum, but also a somewhat atypical situation.

The Erickson site (Appendix 2: 21RO21; Bakken 1988) provides a second example. This is interpreted as a brief-duration, single-use site dating to the Middle Woodland. The lithic assemblage is 97.9 percent Knife River Flint. The site resembles Basswood Shores in capturing a fairly narrow sample of the raw material spectrum. In this case, however, the sample represents a typical rather than atypical event since Middle Woodland assemblages in this part of the state typically have fairly high percentages of KRF (e.g, Clarke 1984).

The model and analysis may also not work well if a collected sample is not representative of the overall lithic assemblage. This could happen if the sample is simply too small, or if it was collected from a context that is not typical of the larger assemblage – a feature, for example. Either factor will be more of an issue at sites with strong intrasite patterning and good distinctions between parts of the site. Ironically this means that the kinds of sites we find most valuable could also be more difficult to analyze in terms of raw material use patterns – unless we are able to excavate a relatively large sample. Conversely, a surface collection from a plowed site might be more amenable to raw material analysis.

Site 21MA28 (21MA28; Murray et al. 1991:40) provides an example of the first situation. The site contained nicely patterned remains, including a small workshop focused on reduction of Swan River Chert, and nearby another focused on reduction of Red River

Chert. Had the excavations been more limited and encountered only one of the workshops, the raw material analysis could have been difficult or the results misleading. In this case, however, the excavation was extensive enough to both retrieve a good sample of the broader pattern of raw material use, and to reveal that certain parts of the sample specific contexts that could not be interpreted in the general terms of the use pattern model.

This example reinforces the caveat that a good raw material analysis goes beyond simply pouring a raw material inventory into an analytical machine. It should also take account of the contexts sampled, as well as the adequacy of the sample in representing both the overall lithic assemblage and the full spectrum of raw material use. In some cases such an accounting might be difficult or ambiguous, but even in those cases it will result in a better utility analysis.

We can also think of this in terms of the statistical concepts of population and sample. The set of all lithic artifacts *existing* at a site is the population; the set of lithic artifacts *retrieved* from a site is the sample. The smaller the sample, the greater the chance that is will not be representative of the population. This is a greater risk, for example, if the sample happens to come from contexts such as a feature that represents reduction of a single piece of toolstone or maintenance of a single tool. This is akin to the problem encountered with very short-duration, single-use sites. The sample represents a very restricted slice of overall raw material use. Hopefully careful examination and interpretation of the sample from a site should identify such situations, and the raw material analysis can be conducted accordingly.

Related to this is the need to keep the issue of sample size in mind. This matter is discussed at length in Chapter 2, and will not be repeated here. This is simply a reminder that small samples are normally unlikely to produce good results in a raw material analysis. If you attempt to conduct a raw material analysis on a small sample, your reporting should explicitly present the results as qualified and not entirely reliable unless you are able to argue that the sample is in fact adequately representative of the population.

Sampling and Context

In order to get the best results from raw material analyses, we might do well to consider both sampling and context. These topics were touched on above in the discussion of practical limitations and potential problems. Here those ideas are examined from the slightly different perspective of research designs. As discussed, the model and analysis may also not work well if a collected sample is not representative of the overall lithic assemblage. This could happen if the sample is simply too small, or if it was collected from a context that is not typical of the larger assemblage – a feature, for example. To keep this from becoming a problem in the analysis stage, we need to evaluate the nature of an assemblage and the likelihood that is provides a representative sample of both the population and the use pattern.

We can also address these issues at the planning stage. Obviously there are many considerations to be addressed in planning projects, among them budget, schedule, and research goals. I propose that raw material sampling and context should be considered along with other research goals, at least when a raw material analysis is part of the overall plan. How exactly such sampling planning unfolds depends on the nature of the site, and it is not possible to anticipate all possible circumstances in this discussion. We can, however, look at a few guiding principals and hypothetical examples. Keep in mind that this discussion is based on the idea of sample (the lithic artifacts we recover from a site) and population (the entire set of lithic artifacts at the size, both the ones we recover and the ones we do not). We normally do not know either the size or the character of the population, although it is usually possible to make some reasonable inferences. The term subsample is used to refer to a set of lithic artifacts from one part of a site, such as a single excavation unit, an excavation block, or a feature.

The first consideration is the need to collect a sample of adequate size. The extended discussion in Chapter 2 suggests, as a rule of thumb, a minimum sample size of about 100 pieces. Research planning should consider whether it is possible or practical to recover a sample of 100 or more lithic artifacts. Keep in mind, however, that there are some circumstances when a smaller sample will yield good results.

A second consideration is to what degree the site is homogenous or heterogenous. For example, a site that was used repeatedly or for a long time is more likely to contain a relatively homogenous distribution of lithic artifacts. Ricing camps like 21CE5 (21CE5; Bakken 1994, 2006b), for example, often fall into this category because they were used each fall for long periods of time. In cases like this, a subsample from one part of the site is more likely to resemble a subsample from another part of the site. One subsample may not adequately represent the population, but a smaller number of subsamples may be adequate.

The opposite is true at a more heterogenous site. A site that was not used for an extended period is more likely to have artifact concentrations that are functionally or otherwise distinctive. Such concentrations or features may not reflect the full range of activities at the site, or the full spectrum of the represented raw material use pattern. The example of 21MA28 (Murray et al. 1991:40), cited above, is referenced again here. Such sites are generally very valuable from a research perspective, but they do introduce complications when it comes to raw material analysis. In cases like these, it is necessary to think in terms of acquiring a larger number of subsamples in order to capture the full spectrum of the represented raw material use pattern.

In the case of surface collection from plowed sites, surface collection sometimes offers an improved chance to collect a larger sample. To the extent that surface distribution reflects heterogeneity within the site, is essential to maintain provenience by conducting a controlled surface collection.

Localizing the Models

Much of the raw material analysis proposed in this thesis can be captured in a spreadsheet that manipulates the numbers from a raw material inventory, produces a series of percentages and graphs, and so accomplishes a basic utility analysis which can then be interpreted by the researcher.[3] Such a spreadsheet applies a uniform analysis to lithic inventories from any part of the state or region. Normally we might expect that such uniformity would be desirable. In the case of utility analysis, however, this is not necessarily the case.

This is because the raw material resource base is not uniform across the state or region. For example, the uniform analysis assumes that Jasper Taconite has very good flaking quality and comes in large package sizes. This is true for the primary source area near Thunder Bay. It is probably not true, however, for large parts of Minnesota that are part of the secondary source area for Jasper Taconite. In the secondary source area, the material occurs in smaller package sizes and its flaking quality is effectively diminished by the accumulation of cracks resulting from weathering and glacial transport. Thus we could expect the uniform analysis to produce better results for sites near the primary source area, but weaker results for sites in the secondary source area.

The results for the secondary source area could, however, be improved by localizing the analysis. Specifically we could move Jasper Taconite within the utility plane, from the "good" and "boulder" range to perhaps the "average" and "cobble" (or even "pebble") range. This acknowledges that the characteristics of the material are different in the primary and secondary source areas and thus, according to the model, the material will be used in different ways in the primary and secondary source areas. Similar adjustments could be made for other

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[3] The spreadsheet exists, in fact, and has been made available for interested researchers.

raw materials. In fact, I suspect it is likely that several adjustments would be needed to optimize the analysis from place to place.

If we think of this again in terms of a spreadsheet the result would be a proliferation of versions, each optimized for a particular geographic context. In one sense, this lack of uniformity could be a liability. This does not need to be the case, however, if researchers are careful to specify how they have classified each raw material in terms of flaking quality and package size. The most practical way to do this might be in the form of a table representing the utility plane, and showing the location of each raw material found in the assemblage.

This also allows individual researchers to incorporate their detailed knowledge of the local raw material base into an analysis. As we capture more and more of this local detail, analytical results should improve. Eventually I would expect the situation to stabilize. We should end up with a fixed number of utility-plane configuration (i.e., analyses), each localized for a particular geographic area, and each optimized for raw material analysis in that area. Ideally each of these will represent a consensus on our best understanding of raw material variability across the region.

Note that localization is also important in examining the movement of raw materials. It is not possible to produce a uniform, state-wide analysis that correctly classifies raw materials as local versus nonlocal. The uniform state-wide analysis must assume that all materials found within the state are local. Prairie du Chien Chert would not be recognized as nonlocal in an assemblage from the Upper Red Subregion, nor would Tongue River Silica be recognized as nonlocal in an assemblage from the Tamarack Subregion. This situation can be easily remedied by localizing the analysis, however, which again leads to improved results.

RESEARCH ISSUES

The models and attendant analyses also point out some potential avenues for related research. Most of these are research issues that we are already aware of. In some cases, however, the models might provide a change of perspective in terms of significance or priority. In other cases, they might simply reinforce our current perspectives and priorities.

Calibrating the Models

I feel that the resource and use pattern models are fundamentally sound, but I freely admit that they require better calibration. In other words, they reflect my best understanding of the distribution of raw materials in terms of flaking quality, package size, and abundance. But my knowledge is incomplete and imperfect. This weakens the performance of the models and the results of the analyses. The current performance is acceptable, but we need it to be optimal.

I would like to qualify these statements somewhat. In constructing and presenting these models I have used the best information I could find on regional raw materials. In some cases this information was quite strong. This assures that the models and analyses perform above a certain basic level. In other cases, however, the information was meager or inconsistent. This is where the problems creep in.

In many cases, researchers may already have better information on raw material resources in the territory they are most familiar with. It should be fairly simple to apply this knowledge case by case. This is akin to localizing the models and analyses, as discussed above. It also goes beyond localization, however. The accumulation of such local information will help us to better understand the big picture. We can build up a better idea of things like primary, secondary and tertiary source zones for individual raw materials, and how utility-plane placement changes between zones.

In addition to capturing such existing local knowledge, we should also think in terms of additional raw material survey. Such surveys could vary considerably in terms of intensity, geographic extent and research methods (cf. Baumler 1988; Braun et al. 2008, 2009; Wilson 2007). Accumulating standardized, quantitative information on raw material package size, for example, could be fairly simple and quite helpful. And even a basic raw material survey of the Pipestone Resource Region would be enormously helpful; simply learning what raw materials occur in the region should be a high priority goal.

Other steps, however, could be more problematic. For example, it would be helpful to have information on the relative abundance of different raw materials, but it is not immediately clear how this information could be gathered. We would need to devise sampling strategies to support systematic collection of all potential toolstone from a defined sample zone. Although this might initially sound fairly straightforward, closer consideration suggests that it might not be. How do you move from opportunistic sampling to systematic sampling that produces comparable results between different sampling locations? How do you quantify availability at a source like the Grand Meadow quarries, where the toolstone was extracted from below the surface? Should a survey only inventory pieces of toolstone that are free of cracks and other flaws, and if so what is the cutoff point? For the moment, I gladly leave such questions for the future.

Although our general knowledge of regional raw materials is good, it is likely that we will continue to discover previously unrecognized materials. We might expect that we now know about all the major raw materials in the state, but even this might be overly-optimistic. This is underscored by Wendt's recent success in distinguishing Fat Rock Quartz from other quartz, which is an essential step in sorting out the complex matter of quartz use in central Minnesota.

Flaking quality also deserves a mention. At present we have a workable assessment of flaking quality for many raw materials. However, since flaking quality is an essential raw-material characteristic in the models and analyses, we can only benefit from an improved understanding of flaking quality. The first step would be to gather and knap regional raw materials, preferably using a variety of reduction techniques and strategies. The effects of heat treatment should also be considered.

In undertaking such an experimental program, we are likely to run head-long into broader issues in assessing flaking quality. Everybody knows good and bad quality when they see it. However, in spite of the good efforts of many highly capable researchers (e.g., Brantingham et al. 2000; Braun et al. 2009; Brown et al. 2009; Luedtke 1992; Noll 2000; Woods 2010), no one has quite been able to create a standard, systematic way to describe or evaluate quality. In part this is because quality is not one single characteristic, but the cumulative effect of several different characteristics. In part it is also because good quality must be defined in terms of such factors as reduction technique, reduction strategy, and desired tool type. What is a good material in one situation may be less than ideal in another. I do not know how much progress we might make on the thorny matter of defining flaking quality, but if we could even be a bit more precise and explicit in our discussion it would be a step in the right direction.

Improving Lithic Data Quality

In general, I feel that the regional lithic data produced since the early 1990s are generally good in terms of raw material identification. They are good enough, in fact, that some identification problems clearly stand out in the data. Problems do remain, however, and we can only get better analytical results – whatever methods we use – if we start with even better data.

Some problems relate to specific raw materials or kinds of raw materials, and I would like to mention cases that I am aware of. The first is the matter of distinguishing Fat Rock

Quartz from other quartz. None of the lithic data I accumulated for this study distinguish the two, with the result that it is not possible to adequately understand use patterns in the Quartz Subregion. The sooner that we can become proficient at recognizing Fat Rock, the sooner we can make progress on this research agenda.

Beyond this, quartz comes from many different sources, and is widely distributed around the state. The quartz from various sources varies in its flaking properties, package size, and abundance. On one hand this suggests that it may be advisable at some point to identify and describe other specific varieties of quartz, and bring them into the resource region fold. On the other hand, most of the quartz beyond Fat Rock probably was only used for pebble core reduction, regardless of its specific characteristics, and there may be little to gain by spending more time on researching the various varieties. Given these considerations, it may be best to carry on with research into the sources, varieties and characteristics of quartz, until such time as we can better recognize the point of diminishing returns.

A second important case relates to chopping tools. Since these are made from a variety of submarginal raw materials, the flakes from their manufacture often lack the basic features we normally use to distinguish flaking debris from naturally broken rock. In addition, these raw materials lie outside the range of what we normally recognize as toolstone. The data on chopping tool raw materials show very little if any patterning. This suggests that recognition and collection of chopping-tool flaking debris has been haphazard and inconsistent. I would urge researchers to focus some attention on this matter, and make a best effort to begin systematically collecting these artifacts. It will probably take some time to reach a kind of consensus on what legitimately constitutes chopping-tool flaking debris, and it is not presently clear what characteristics we need to consider. I would only suggest, however, that we begin by paying attention to the kinds of materials we see in the chopping tools themselves, and also examine the chopping tools for clues to the characteristics of the flakes detached during their manufacture.

Related to this is the idea that some of the basaltic rock, quartzite and similar materials might represent not chopping tool manufacture, but incidental damage to hammerstones. To whatever degree this is true, it would still be prudent to apply ourselves to identifying and collecting these artifacts. Conceivably they might provide insight into the use of hard hammer percussion, or its absence.

There has been a longstanding problem with consistently distinguishing between Knife Lake Siltstone, Lake of the Woods Siltstone, and Lake of the Woods Rhyolite. Many artifacts can be confidently associated with one or the other raw material type, but it seems there are usually a few ambiguous pieces. The proposed Border Lakes Greenstone Group goes some way towards minimizing this problem, by saying that in the proper circumstances it is not important to distinguish between the raw materials included in the group. In other cases, however, it would be best to be able to consistently and confidently separate the materials. As is usually the case, this becomes more important as you get closer to the primary sources. In the area between Lake of the Woods and Knife Lake, for example, it could be potentially important to know whether materials were coming from western sources, eastern sources, or some currently unrecognized local sources. In addition, there are still questions about relative flaking quality and how these materials are being used. It is probably reasonable to think that the two siltstones are very similar in terms of quality and in how they were used. However, although the current model assumes similar flaking quality and use for the siltstones and rhyolite, it is not clear that this is actually the case. Technological analyses and experimental knapping might go a long way toward resolving this question.

Much the same might be said about the Hixton Group orthoquartzites. At present the model treats them as interchangeable, essentially equal in flaking quality and in how they were used. Again, however, this is only an initial assumption. The matter also deserves closer attention. The Animikie Group silicates present a similar situation.

There is also some confusion that centers on Hudson Bay Lowland Chert. As best I can determine, to the northwest there has been some confusion in distinguishing HBLC and Red River Chert, while to the northeast the confusion has involved distinguishing HBLC and Knife River Flint. This is somewhat surprising, given that RRC and KRF do not resemble each other in any obvious way. I would suggest that the resemblance between HBLC and either other material is also not that great, and that any attendant confusion can be fairly easily resolved. There are probably two main contributing factors. First, the lithic reference collection at Fort Snelling lacked good samples for HBLC and RRC. That situation has been at least partly remedied, and further efforts are being made to obtain an even better set of samples. Second, both HBLC and KRF are relatively uncommon in large parts of the state, and many researchers have little opportunity to develop a strong familiarity with the materials. The simplest solution is probably to continue to do what we already do – solicit second opinions, especially from researchers with different regional expertise.

We might try to specifically identify what raw materials are included in the Western River Gravels Group, although it might be best to approach that job with some caution. The group includes a large number of materials from a large geographic area. Connecting materials to sources could be a big job, and one where limited analytical benefits would not justify the time and energy required. In general, it is probably more efficient and just as informative to simply learn to identify constituents of this group without worrying about specific raw material identification. On the other hand, in a few cases there could be other potential benefits. For example, it is not presently clear how some materials of western origin were introduced into local sediments. Knife River Flint and silicified wood are two cases in point. It might be useful to know whether they arrived here via preglacial river gravels or some other mechanism, and thus whether they are actually members of the WRG Group (see Chapter 3, discussion of Tongue River Silica). If they are, we might also try to determine whether other specific materials from the western Dakotas arrived here in the same way, so that we do not automatically take their presence in local assemblages as evidence of trade or other contact. Beyond that, it might be helpful to identify the most common materials in the WRG Group, simply as an aid to their reliable identification.

One useful step might be to increase our efforts to identify materials originating from places like the western Dakotas, Iowa, and even farther afield.[4] Although these materials normally constitute only a small percentage of regional lithic assemblages, they can provide potentially useful information. In some cases such data might suggest some kind of strong link with distant raw material sources, but in general it would probably be more useful in evaluating how much raw material is moving around in different periods, and in what form.

Finally, it is worth thinking for a moment about accurate identification of similar raw materials from adjacent regions. Red River Chert, for example, overlaps somewhat with the visual characteristics of Grand Meadow Chert and Prairie du Chien Chert. It is helpful to remember that this does not need to be a big problem since the source region for RRC is largely separate from the source areas for GMC and PdC. Wherever we can improve accuracy in identifying regional materials with overlapping characteristics, however, we do improve overall accuracy of results.

Looking at Lithic Technology

At this point, we know little about how the raw material use patterns relate to the underlying technologies, reductions strategies and tool types. Although this is an important issue, it is not addressed in this thesis beyond a few suggestions and questions. This was a deliberate choice, made to hold the research to a more manageable scope. A full understanding of raw

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[4] Recent additions to the lithic reference collection at Fort Snelling should be very helpful in this regard.

material use patterns, however, requires making connections between pattern and technology. This should be a very achievable goal, one that we can tackle by subjecting assemblages to both raw material and technological analysis. I would anticipate that this would be a very fruitful avenue for future research. To help promote this, I would like to make a few observations about a few specific issues that we could begin addressing.

One of the propositions put forward in this thesis is that three of the four patterns relates to different core-reduction strategies. This needs to be examined explicitly, to see whether the proposed associations hold true. We should ask whether B-pattern assemblages are in fact associated with large, patterned cores intended to produce large flake blanks, as suggested by information of the sort we have from the Beauty Lake site. Beyond this, we could examine whether the larger bifaces also served to produce flakes for use as expedient tools. We might ask whether the B pattern also includes patterned cores intended to produce prismatic blades, as suggested by evidence like that from the Pelland blade cache (Stoltman 1971). To what extent can we see opportunistic use of cobble cores to produce bifaces, as suggested by evidence from the Greenbush Borrow Pit site? To what extent do we see the use of hard hammers, soft hammers, or pressure flaking?

For the C and P patterns, we need to ask whether the normal pattern is in fact midsized cores that are not patterned. Are such cores intended to produce midsized flakes that can be reduced into smaller bifaces, without the intention that the bifaces also serve as a source of useable flakes? We might also try to determine the normal source for flakes that are used to produce other tool types, especially end scrapers.

Research into the bipolar reduction strategy of the P pattern should be especially interesting. We currently understand very little about the products of this reduction sequence. Were the main products a series of flakes used as expedient tools, or the core itself which might be reduced into a projectile point for arming arrows? We could examine the balance between cobble cores and pebble cores, and see what parts of the technological system were fed by each. In addition, we might ask whether the pebble-reduction strategy was an "emergency tactic" that is sometimes associated with other patterns.

Another line of fruitful research could involve looking at tool inventories in terms of the utility plane and XYZ conceptual space. This could help us better understand strategies of raw material allocation. Is it the case that tool types located nearer the centrum in the utility plane have priority for the more desirable raw materials, or this too simple a view?

We might also examine some specific phenomena, such as the occurrence of "flake points." If we think about such objects in light of an overall raw material use strategy, can we understand the circumstances where they might be produced in lieu of the usual bifacial projectile points? This research could even be extended in the direction of testing the aerodynamics of flake points versus bifacial points, to see if the greater material and energy costs of producing bifacial points provided clear benefits in terms of increased projectile range or accuracy (e.g., Brooks et al. 2006; Hughes 1998; Shea 2006; Sisk and Shea 2009). These and many similar lines of inquiry will be needed to really understand raw material use in the region.

Testing the Models

In ordinary scientific procedure, a model is first proposed and then it is tested. The goal of this testing is to disprove the model. If the model is not disproven, the testing may still serve to point out how the model may be revised or refined. This would be the upcoming agenda for any researchers who feel that the models presented here merit the time and energy. And simply stated, we can test the models by using them. If they do not serve to explain or predict our observations, our archaeological data, we can say that the models are disproven. If they serve imperfectly, we can say that the models are correct at some level but flawed and that they must be revised and refined. Much of the discussion in this final section of the thesis deals with specific ways that the models can be evaluated, tested, revised or refined.

One way that we can move forward with this is using the models in the course of regular CRM work, whether this is survey, evaluation or mitigation. This has the potential to move the agenda forward steadily, since considerable time and effort are spent on CRM-based research each year. Many new sites are discovered and analyzed, and each one can contribute to a cumulative test of the models. Some sites may be better suited to this than others, of course. It may be difficult to successfully apply the models with the small samples that are typical of many shovel-test surveys. Keep in mind, however, that this obstacle can sometimes be overcome by aggregating data from related sites in order to boost sample size. It might be legitimate, for example, to group all ceramic sites from a survey, or all aceramic sites. The models can then be applied to the aggregated data if an adequate sample size is achieved.

Alternatively, it might be profitable to re-examine previous collections and re-analyze the lithic assemblages using this new approach. Much of the research presented here is a version of just that, in fact – a re-examination of data from hundreds of site investigations undertaken over the past few decades. What I am suggesting in terms of testing the models, however, is perhaps an actual re-examination of collections. This would involve not just generating up-to-date raw material inventories, but ideally taking a fresh look at the associated technologies and typologies. This could be especially useful if it was applied to a few key sites. Examples might include sites with multiple, stratified components; with especially well-preserved intrasite patterning; well-dated sites; or sites where a good overall understanding of the site could guide our interpretation of the raw material. Re-examination could also involve obtaining new radiometric dates for previously studied sites, based on archived datable samples.

It is certainly possible that testing will disprove the models. In this case we may still have made some progress in terms of how we think about and talk about lithic raw material use and lithic technology in our region. I certainly hope, of course, that the models will stand. Then we could begin the business of making them work better.

Chronology

It may be worth a brief reminder that we need more absolute dates for sites in the region. One handicap in this analysis was a paucity of either absolute or relative dates for the many assemblages represented in the total data set. Had more of these assemblages been dated, the task might have been simplified – it can be challenging to study change through time when you cannot properly control for chronology. The problem is compounded further by a lack of reliable regional projectile point chronologies, and by some lingering confusion about ceramic chronologies.

Understandably, many sites lack the sorts of organic samples from good contexts that could provide meaningful radiocarbon dates. Many sites, however, do produce suitable ^{14}C samples that are not dated. And valuable chronological information could be gotten for other sites using techniques like thermoluminescence.

I would hope that we come to think of absolute dating as the norm, rather than as an option to be attempted in ideal circumstances. Without a much larger suite of dates, we will be largely hobbled not only in sorting out raw material use patterns, but also in understanding the prehistory of the region in general.

Geographic Extent

If the resource and use pattern models prove viable in this region, it might be that they will also prove useful in other areas. It would be interesting to see to what extent this turns out to be true. Initially it seems that they might prove useful in other regions where most or all toolstone comes from glacial sediments. The models would have to be localized to account for different sets of raw materials and different raw material distributions, of course, which would be a substantial undertaking.

However, if this proved feasible we could begin to accumulate comparable analytical results from a much broader area. This could open potentially valuable research horizons, and allow us to ask some new and interesting questions. For example, we might examine whether the Pebble Core pattern originates in one area and spreads chrono-transgressively to other regions, or whether it appears in different areas and eventually coalesces over a broader territory. Or we might compare the raw material resource bases for different areas and see how this affects the evolution of lithic technology.

Questions like these, however, are better entertained after more immediate issues like calibrating and testing the models. Should the models prove to be useful tools, there would then be time to think of how to extend the geography of their use.

BROADER CONTEXTS

Use Patterns and Culture History

It is tempting to identify each of the four raw material use patterns with the four major culture-historical traditions and say, for example, that the Boulder Core pattern equals Paleoindian, Cobble Core equals Archaic, and so on. In fact there does seem to be some general correspondence, but the real relationship between patterns and traditions is likely to be more complex. In an earlier discussion, for example, it was suggested that there is a good correspondence between Boulder Core and Paleoindian to the west but that Boulder Core appears to continue into the Archaic to the east. As we investigate further, it is conceivable we could find that the Pebble Core pattern appears earlier in some toolstone-poor areas, perhaps in the Late Archaic, while in other areas it does not predominate until the Late Woodland. We might even find unexpected results like Pebble Core assemblages appearing intermittently in Paleoindian assemblages.

On one specific point, it is not at all clear whether the Pebble Core pattern largely corresponds with the Woodland Tradition. It may well appear at some point during the Woodland, at some point like the end of the Middle Woodland when the distribution of Knife River Flint lessens. Alternatively, it might relate to the some technological shift like the adaptation of the bow and arrow. Such a finding might suggest that it is possible to make arrow points from pebbles, while making dart points from pebbles is generally difficult. These ideas are, however, only speculation at this point, and what actually happened will only become apparent based on further research.

Forces Driving Pattern Changes

Although it is difficult at this stage to identify what caused a change from one pattern to another, this would seem to be a particularly rich field for future study. Untangling the causes for change – as well as related matters like the scale and timing of changes – could provide us not only with a better understanding of lithic systems, but even with a clearer picture of our prehistory and history in general.

It is tempting to explain the changes only in terms of raw material supply and demand. In fact it is not difficult to construct a plausible explanation for many observed changes in this way. We can, for example, posit a situation of growing population, decreased geographic range, and static raw material availability. In such a scenario, the combination of population growth and decreased geographic range pushes the system to a threshold where raw material demand exceeds supply (as in the hypothetical scenario reviewed in Chapter 4). At that threshold, the raw material use pattern changes. Raw material provisioning is reorganized to make use of resources that were previously ignored, thereby increasing the amount of available toolstone. Accompanying this is a technological reorganization, including new reduction strategies and tool types that can be supported by the new provisioning strategies. Further changes in population or range bring the system to another threshold, which precipitates another reorganization of raw material provisioning and lithic technology. These systems are also affected by changes supplies of nonlocal materials, and especially the highly desirable exotic materials like Knife River Flint.

This could be a seductive hypothesis, but perhaps it is based mostly on armchair speculation about what might make sense instead of on evidence and what we actually know. This explanation also has a few weaknesses. For example, as presented it proposes stable raw material availability. But was that actually the case? It may be that local raw material availability changed through time, at least in some regions, and this could have had serious effects (cf. Dibble 1991; Kuehn 1982). Beyond this, do we know that population generally increased through time, or that geographic range shrank?

A more serious objection is that human societies are part of other, larger systems. For example they also interact with plant and animal communities, and with climate. Such interactions also shape economic and technological systems (cf. Fitzhugh 2002, 2004). A population that depends to a significant degree on fishing may have different technological requirements than a population that depends mostly on hunting large game, and this might be reflected in lithic technology. The same kind of comparison might be made for wild rice gathering versus corn horticulture, or dealing with the cold winters of southeastern Minnesota versus the frigid winters of northwestern Minnesota. In addition to such geographic or subsistence differences, we need to consider whether ecological or climatic changes might have contributed to changes in lithic technology and raw material use.

There is also a broader cultural context. The raw material use patterns appear to have been geographically broad, meaning that they crossed social and cultural boundaries. Apparently the adoption of a new raw material use pattern was a deep-seated and widespread change, in effect a paradigm change that could transcend local toolstone characteristics. We need to be mindful that this kind of widely-shared behavior could conceivably have originated in one place and then been adapted in others, perhaps independent of the kinds of supply and demand factors envisioned above. We see an example of this at the Knife River Flint quarries, where bipolar pebble reduction was apparently practiced in spite of a great local abundance of superior quality toolstone (Ahler 1986:54, 108; Ahler and Van Nest 1985).

The interaction of raw material supply and demand, of population and territory and availability, may turn out to be an important factor. We need to bear in mind, however, that it is unlikely to be the only factor.

Lithic technology did not, of course, exist in isolation. It was part of a larger system that included other technologies (cf. Bamforth 1986; Torrence 1983, 1989). As we make progress with understanding lithic technology, we will need to pause from time to time and look at how it relates to other technologies. What happens, for example, to raw material use with the appearance of ceramics? Do bone tools sometimes take over the functions of some stone tools and thus affect raw material provisioning strategies? Can we also understand groundstone tools in the same kind of terms when it comes to raw material provisioning strategies? These are a few examples of what could be a fruitful line of inquiry, and I limit my input on this to a reminder rather than an outline of a research agenda.

It may also be profitable to consider the interaction between lithic technology and environmental factors. To what extent do changes in lithic technology and raw material use seem to relate to broader environmental changes? We might consider, for example, how environmental changes affect raw material availability. Did the Altithermal drying of the plains limit access to the Knife River Flint primary source area (e.g., Loendorf et al. 1984)? Did changing precipitation patterns affect the erosional exposure and concentration of some kinds of toolstone (e.g., Kuehn 1982)? These and similar questions might be added to the general agendas of broader interdisciplinary research related to environmental history.

CONCLUSION

Hopefully the perspectives, methods and models presented here will be one step towards asking – and then answering – questions about very broad patterns of technological and economic history, the relationships of humans to their geological environment, and more. By better understanding the underlying raw material resource base, and having an agenda to keep improving that understanding, we should be able to focus more and more closely on the cultural aspects of raw material use in the archaeological record. By looking at lithic assemblages through the lens of quality, size and intensity of use, we may be able to better understand lithic technologies and raw material economies in ways that have proven elusive so far. Hopefully these tools will also facilitate effective and efficient communication on those topics.

Understanding lithic raw material use in the glaciated landscape of the Upper Midwest is a formidable challenge. The complex toolstone resources of the landscape may also, however, prove to be a unique research opportunity once we have the right tools to deal with the complexity. Once we have the right concepts, vocabulary and methods to ask the right questions of the lithic record, we stand to get some very interesting answers.

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Appendix 1. Statewide distribution in Minnesota for selected raw materials, showing relative abundance by county and for sites with larger samples and better data quality.

The maps in this appendix show the percentage of various raw materials by county and for selected sites. The county data come from the set of better quality data, except for a few sites excluded for reasons discussed in Chapter 2 (see also Appendix 3). The site data come from a set of 221 assemblages with adequate sample size and some associated information on chronology or general cultural affiliation.

The order of presentation follows that used in raw material data tables in the general text (see "Contents of Appendix 1" below). All raw materials discussed in the general text are included in the maps, with the exception of a few materials for which good data were not available. All but Fat Rock Quartz are minor materials. In addition, the distributions of individual generically-identified and unidentified raw materials did not seem informative, so these are mapped in aggregate.

Note that division of the percentage scales vary from map to map, according to the characteristics of each data set. This preserves a visual comparability in the maps. The scales and division were calculated by a Jenks function available in ArcMap.

In the following list of contents, "n=" indicates the number of identified specimens in the mapped data set.

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Appendix 1-25	Lake of the Woods Rhyolite	4,205
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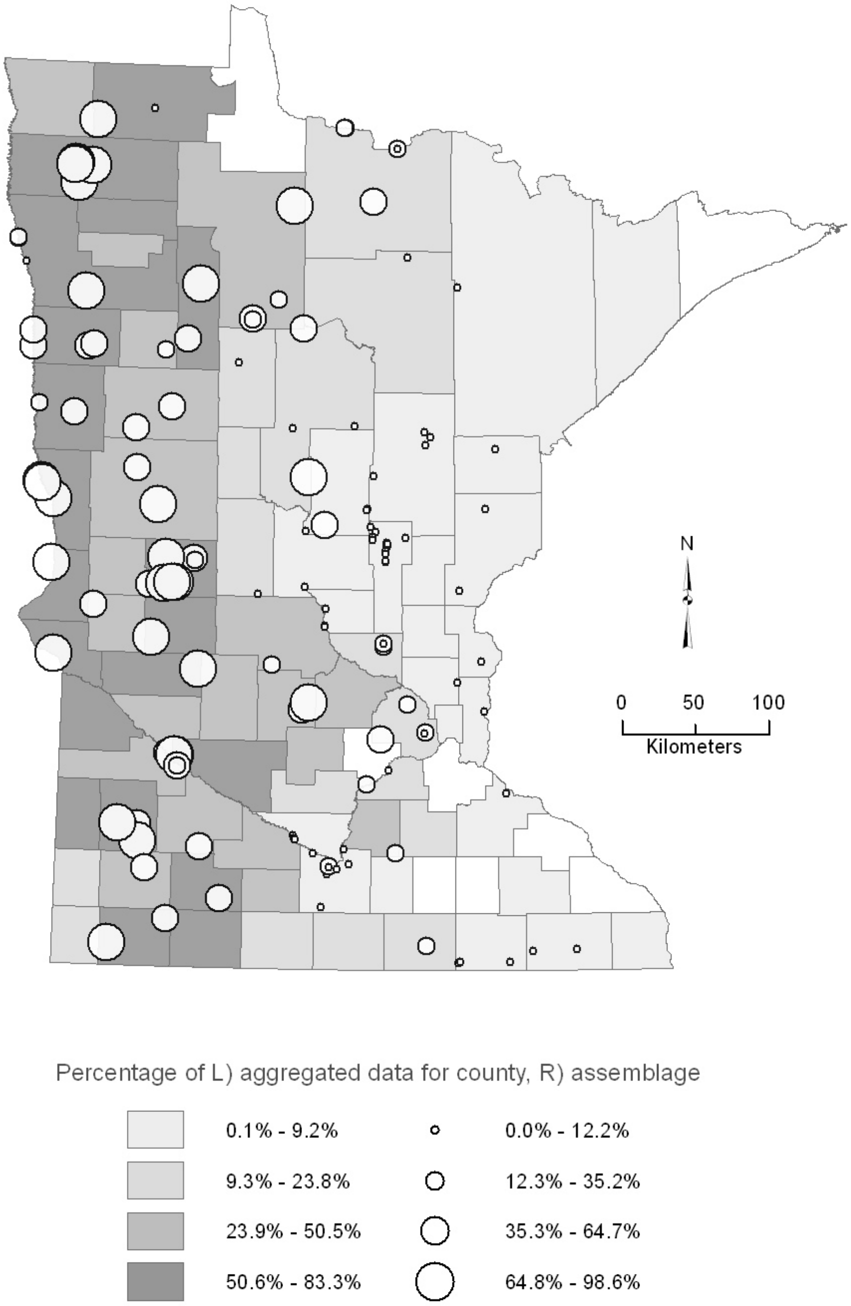
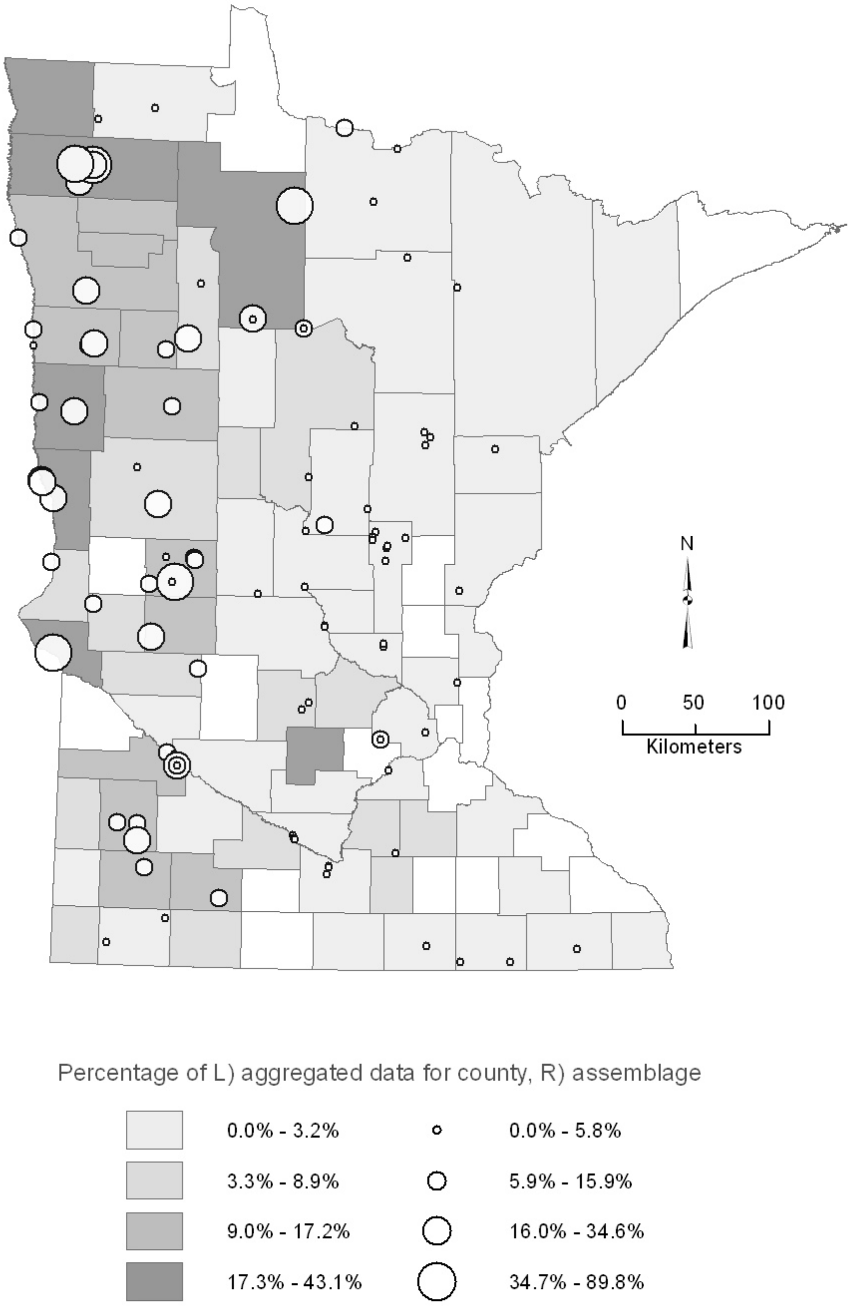
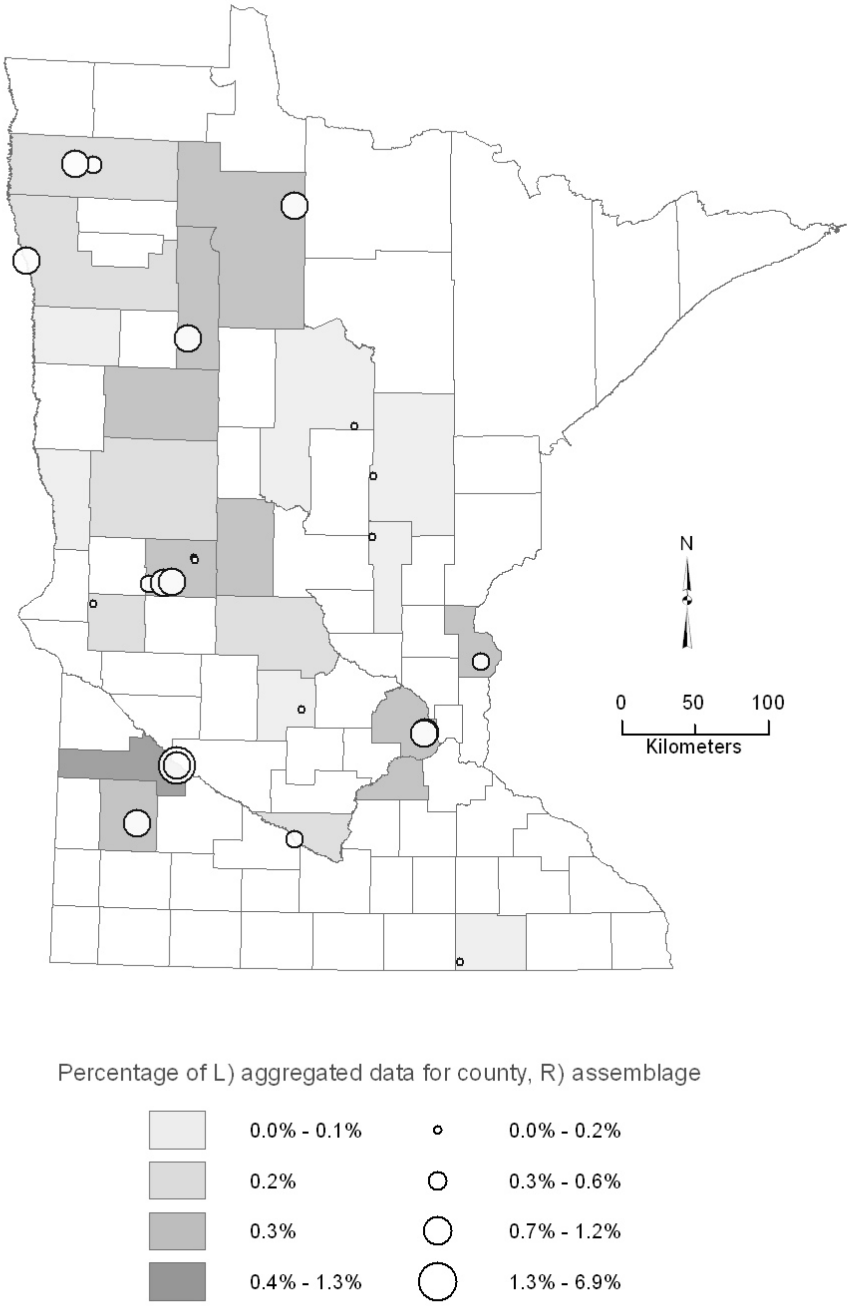
Appendix 1-1. Statewide distribution of South Agassiz raw materials by county and for selected sites.



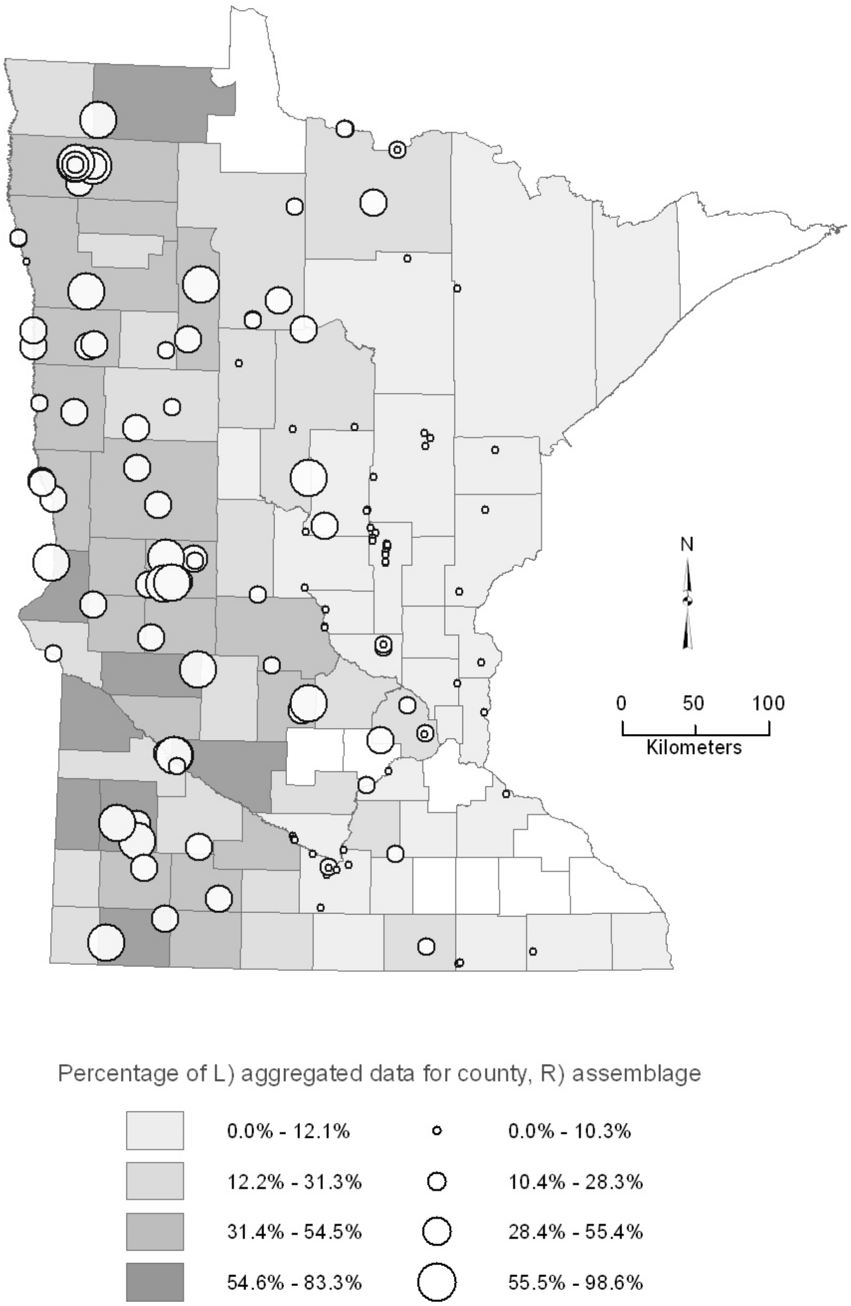
Appendix 1-2. Statewide distribution of Red River Chert by county and for selected sites.



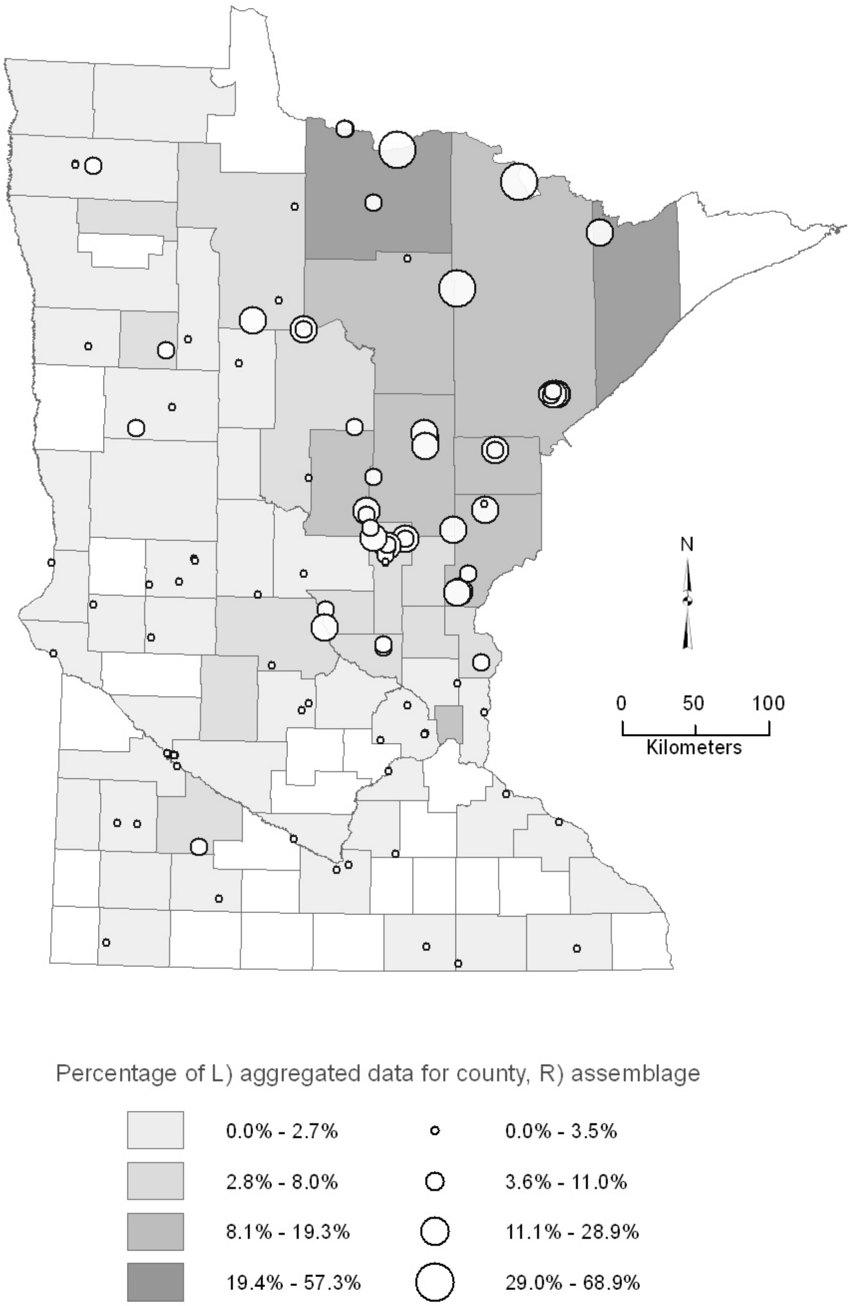
Appendix 1-3. Statewide distribution of silicified wood by county and for selected sites.



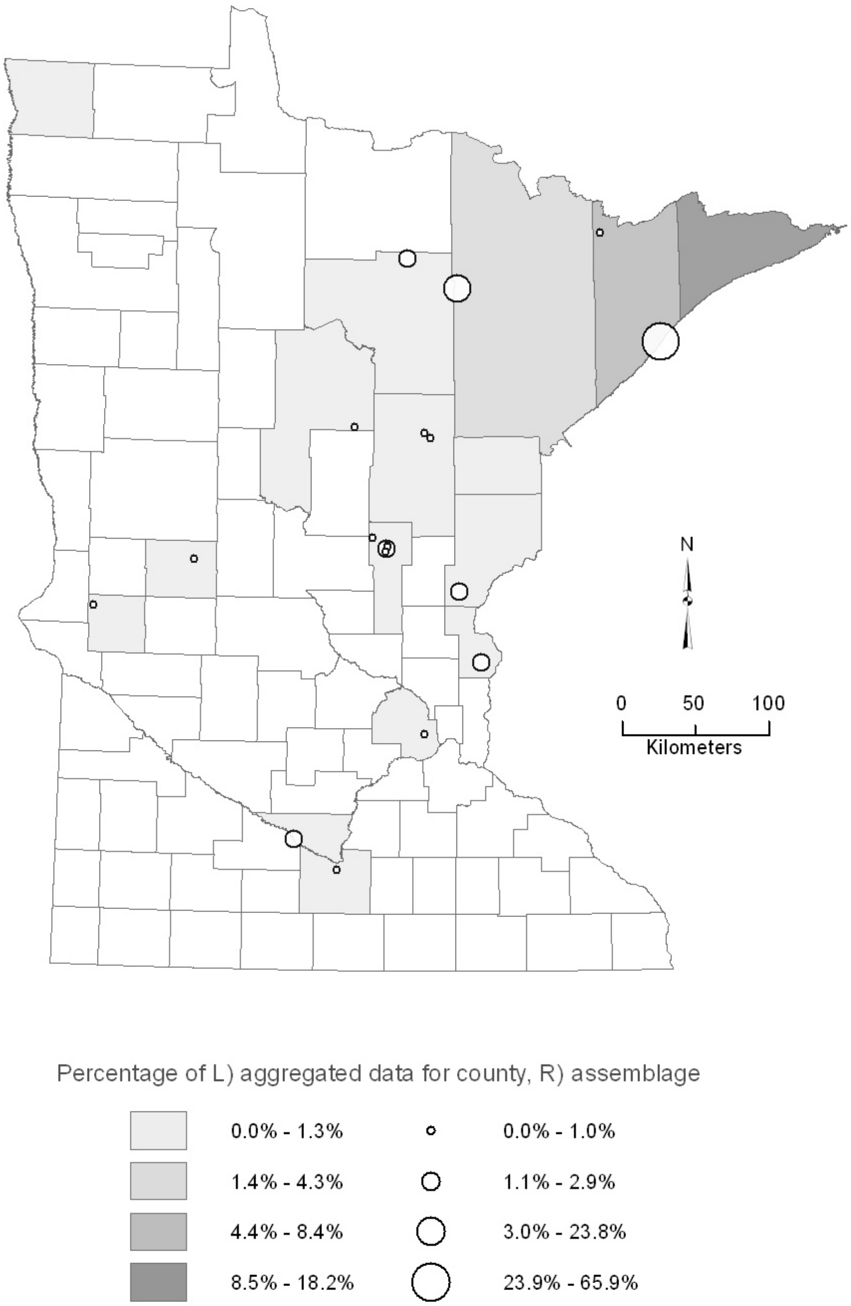
Appendix 1-4. Statewide distribution of Swan River Chert by county and for selected sites.



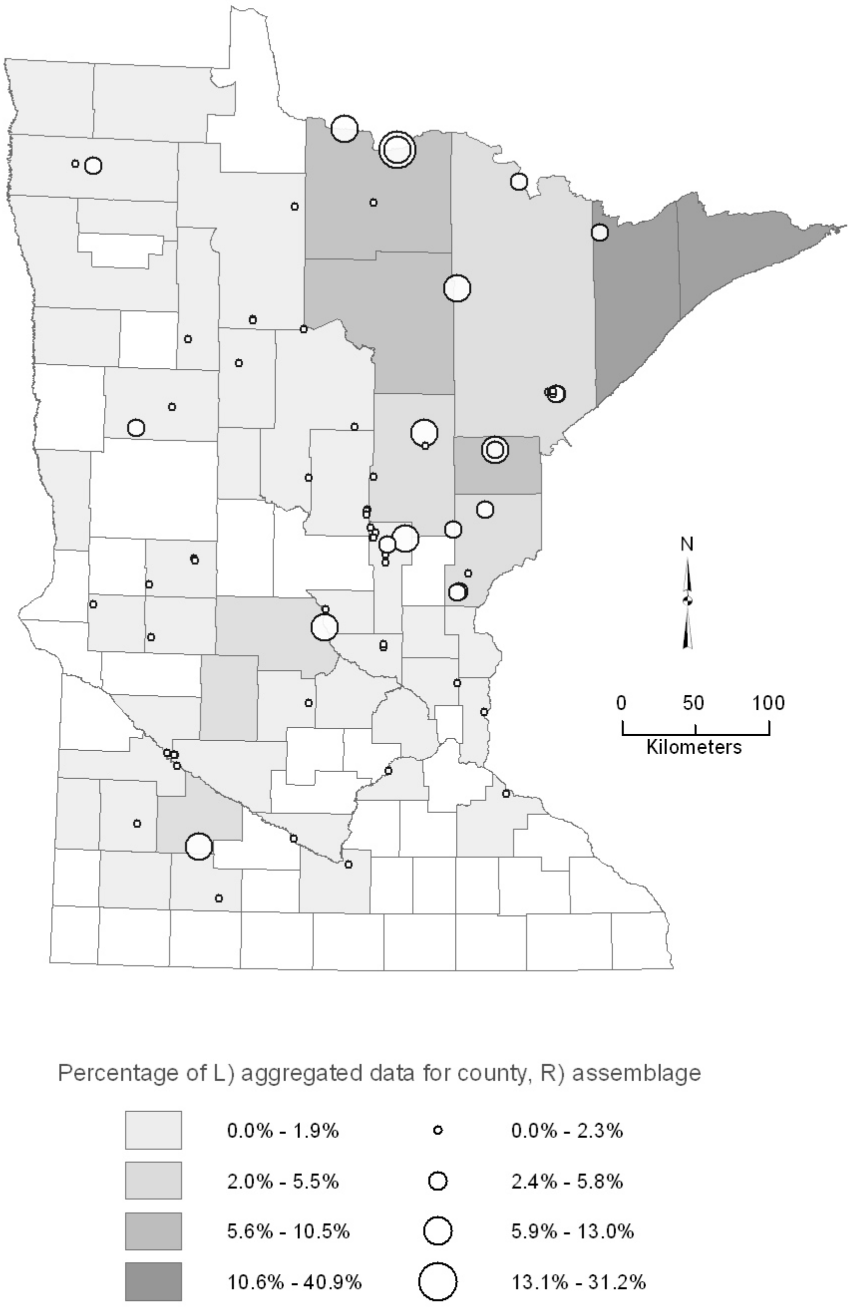
Appendix 1-5. Statewide distribution of West Superior raw materials by county and for selected sites.



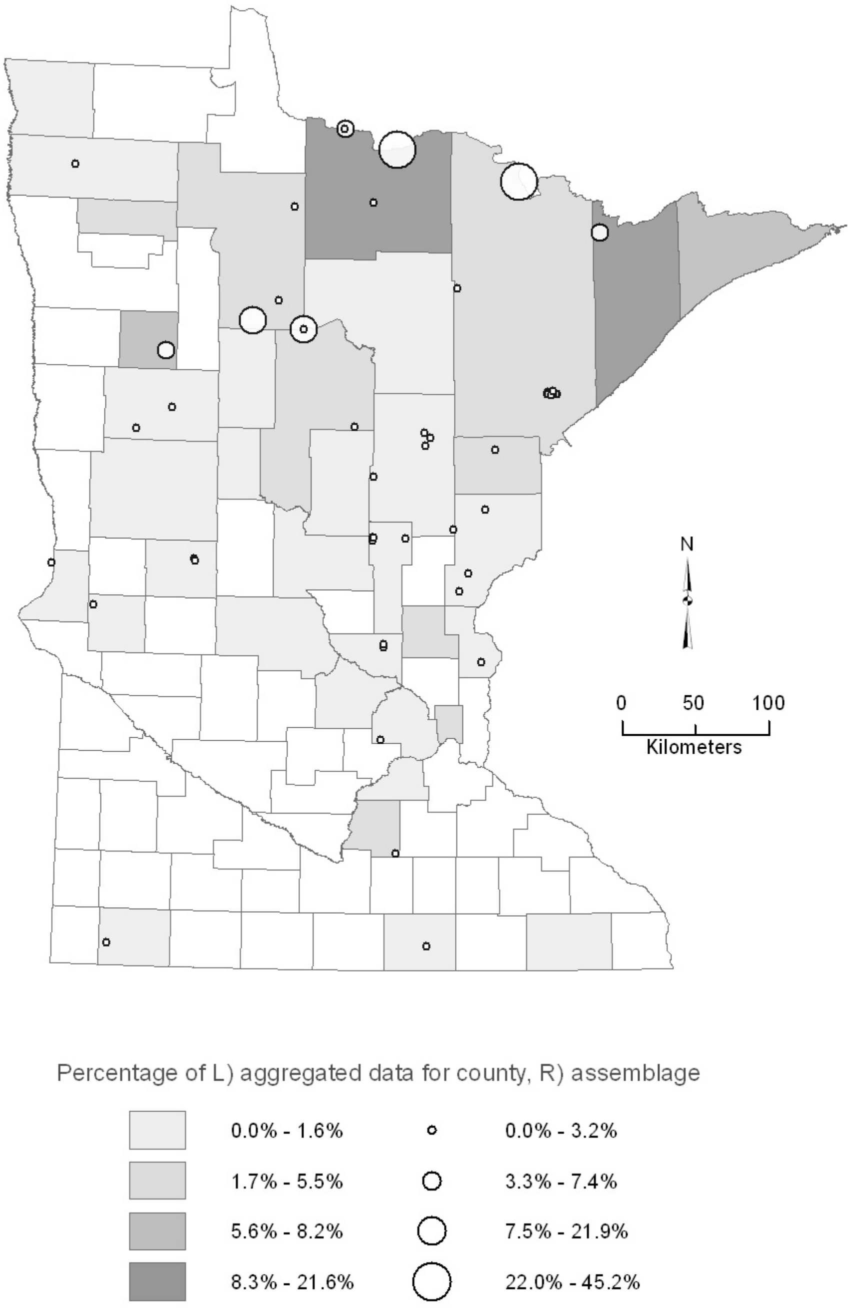
Appendix 1-6. Statewide distribution of undiferentiated Animikie Group raw materials by county and for selected sites.



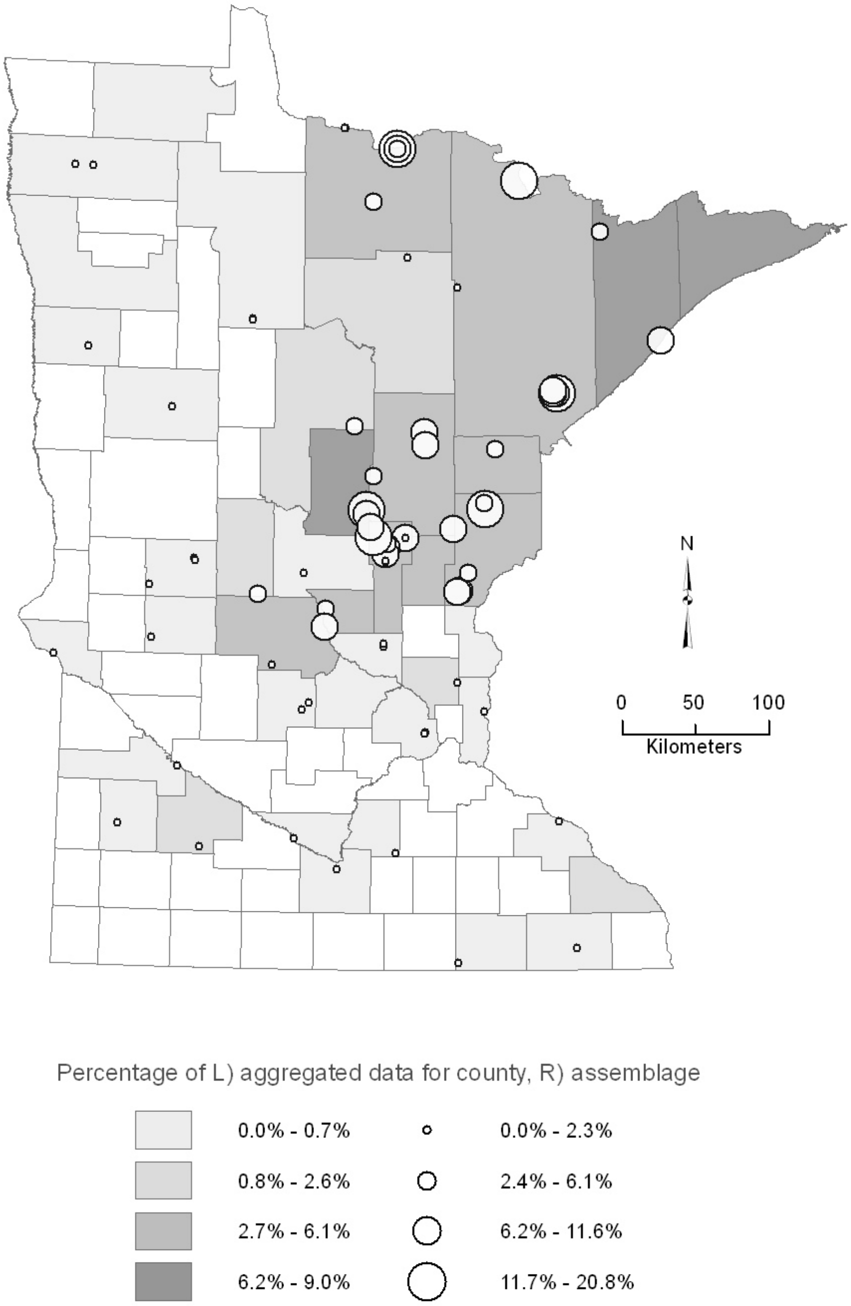
Appendix 1-7. Statewide distribution of Gunflint Silica by county and for selected sites.



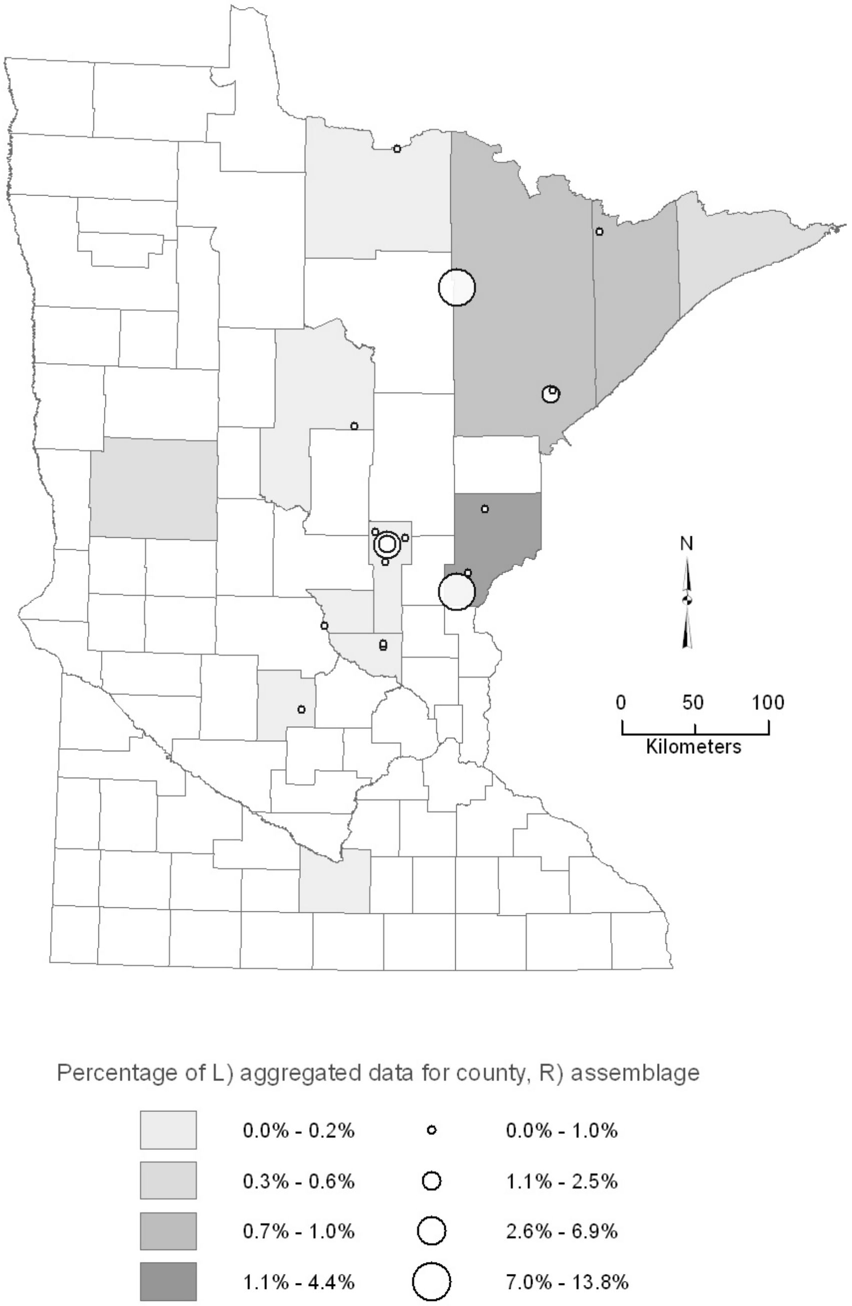
Appendix 1-8. Statewide distribution of Hudson Bay Lowland Chert by county and for selected sites.



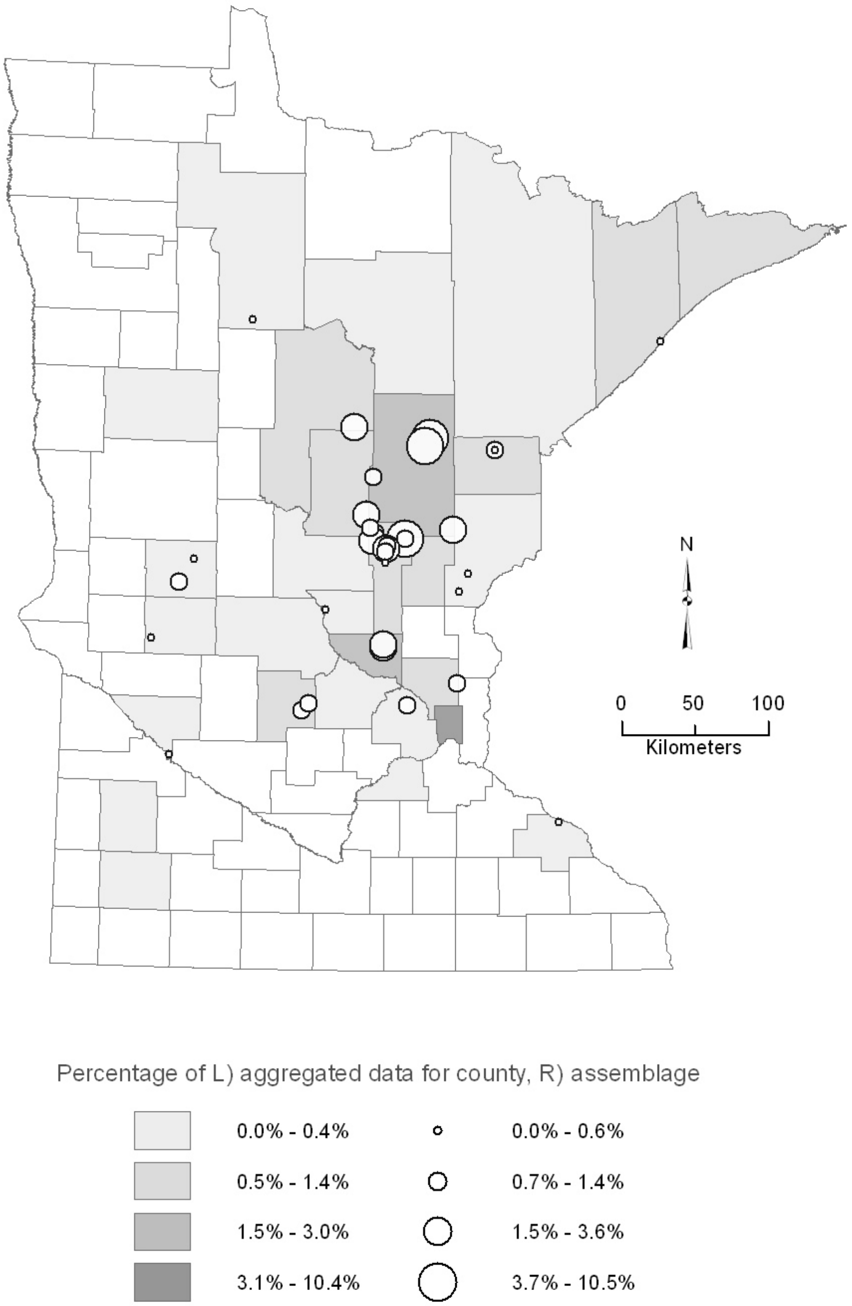
Appendix 1-9. Statewide distribution of Jasper Taconite by county and for selected sites.



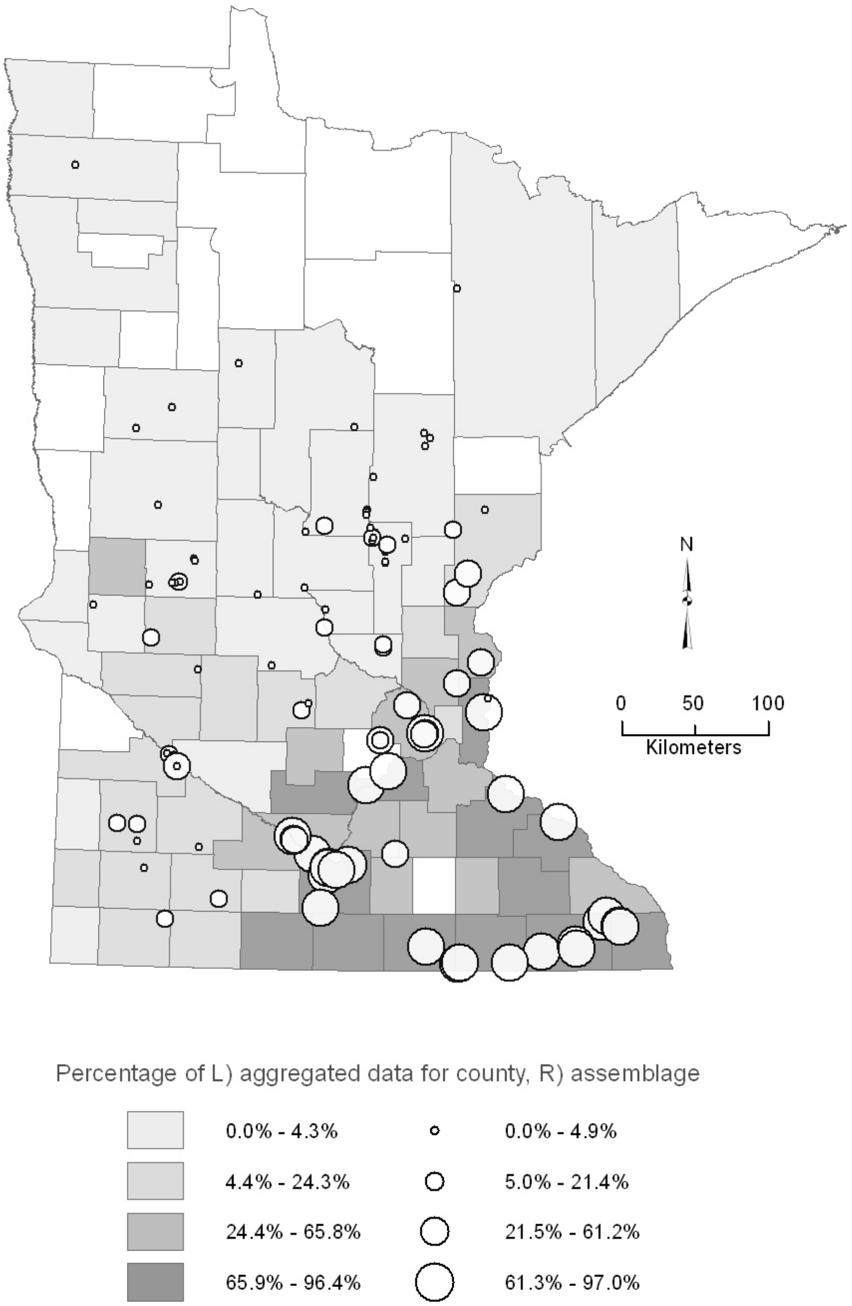
Appendix 1-10. Statewide distribution of Kakabeka Chert by county and for selected sites.



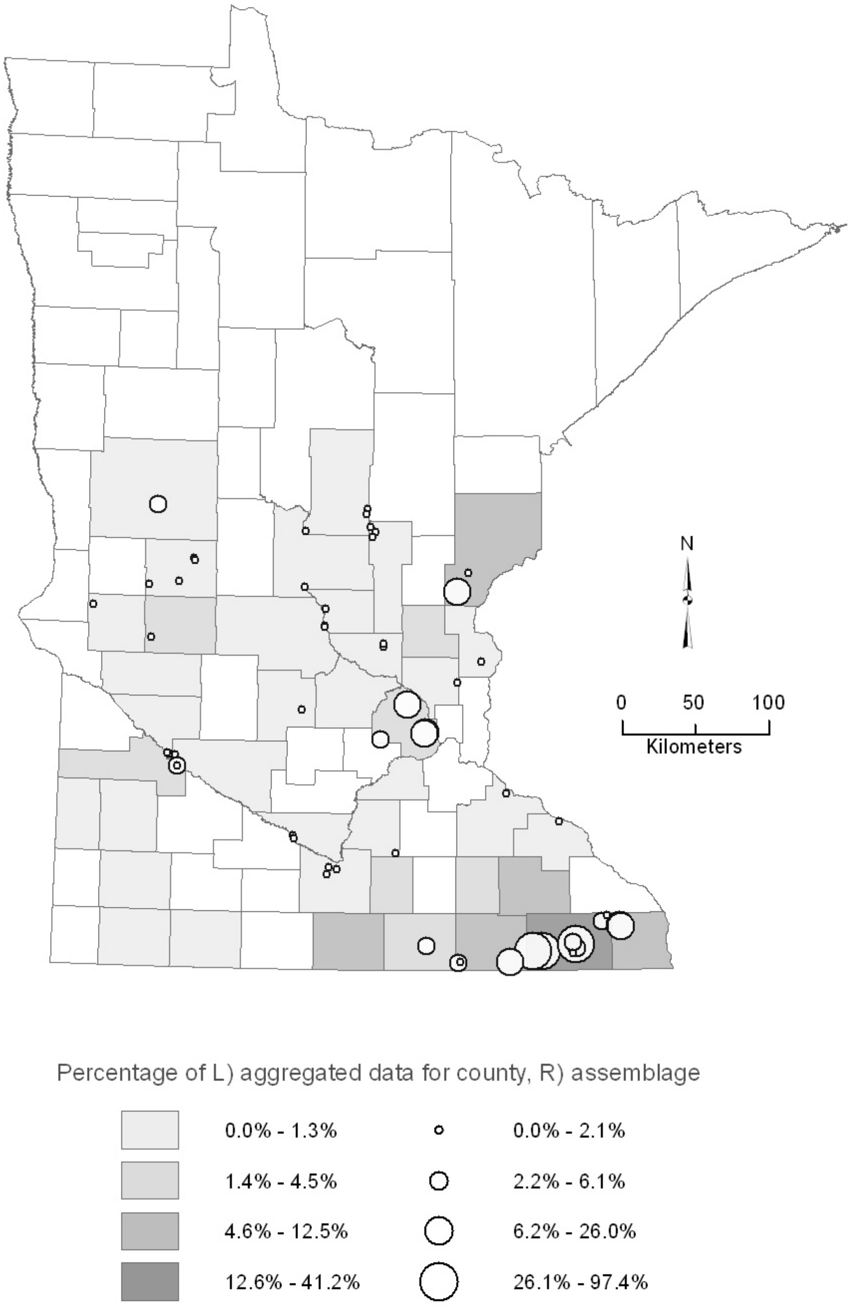
Appendix 1-11. Statewide distribution of Lake Superior Agate by county and for selected sites.



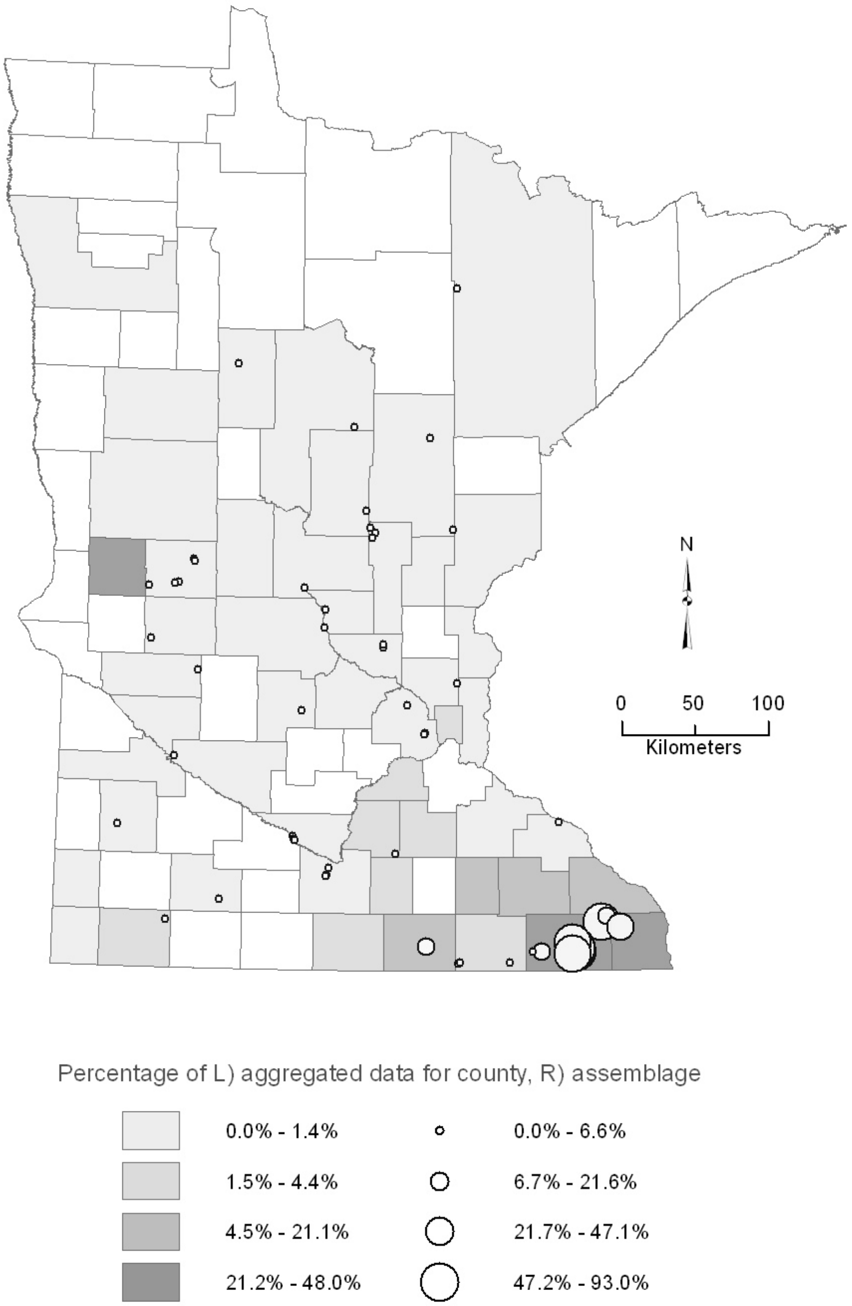
Appendix 1-12. Statewide distribution of Hollandale Resource Region raw materials by county and for selected sites.



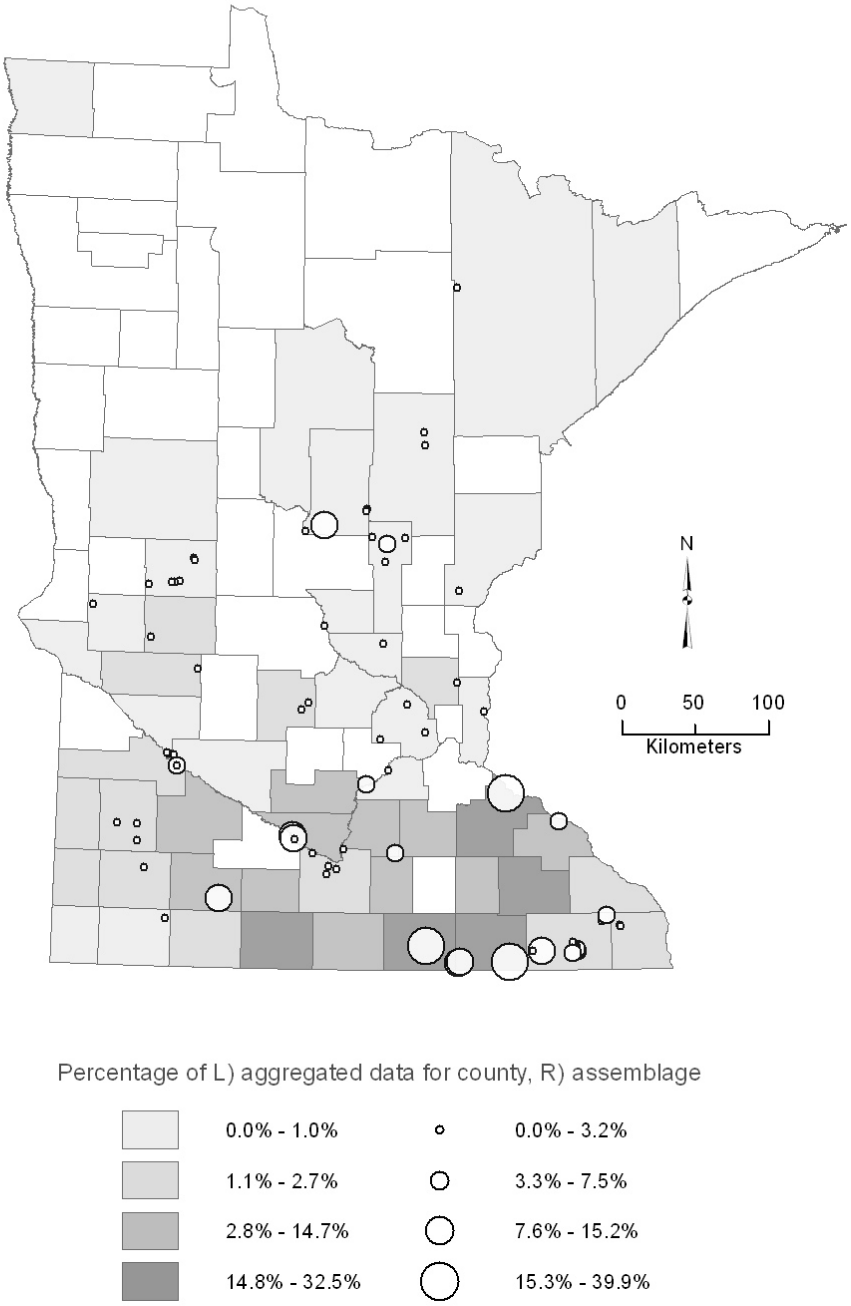
Appendix 1-13. Statewide distribution of Cedar Valley Chert by county and for selected sites.



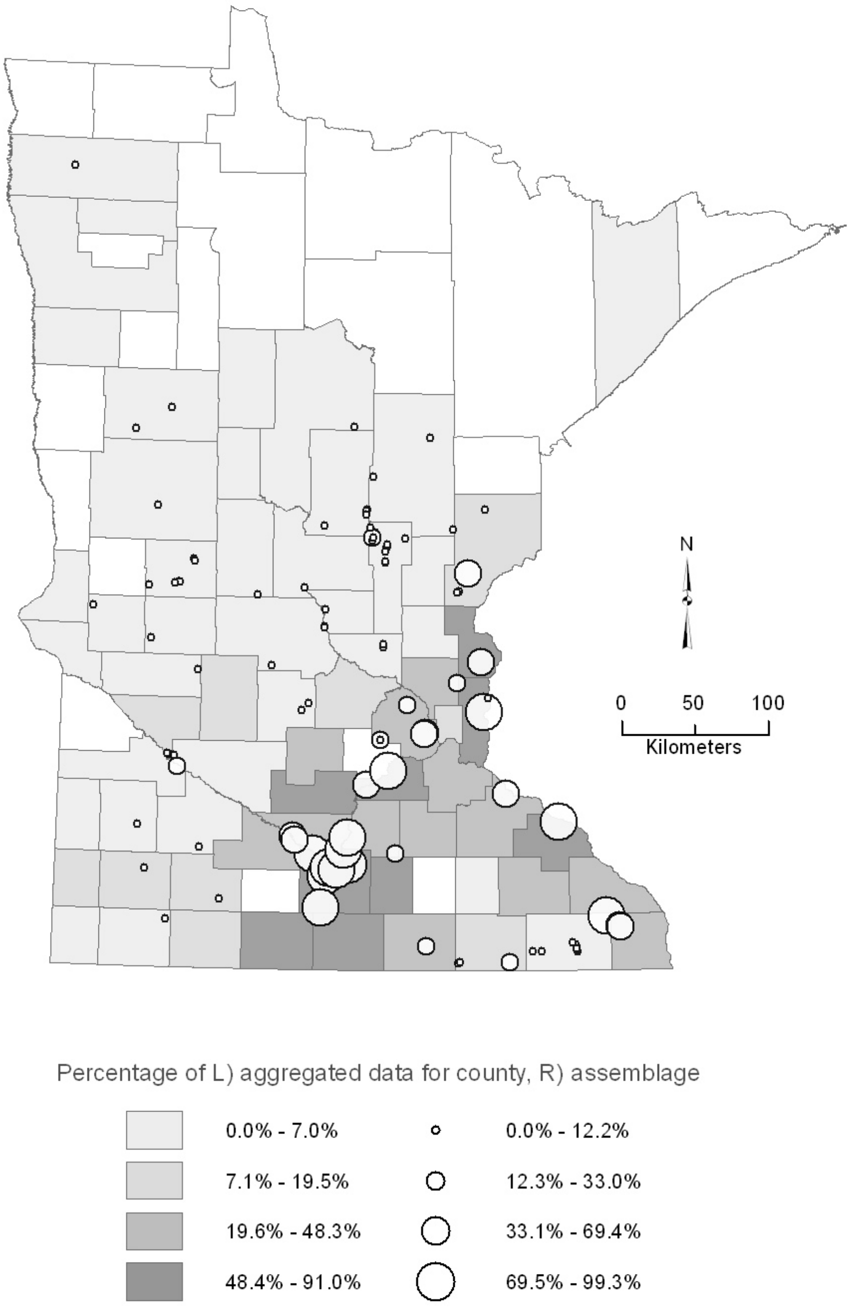
Appendix 1-14. Statewide distribution of Galena Chert by county and for selected sites.



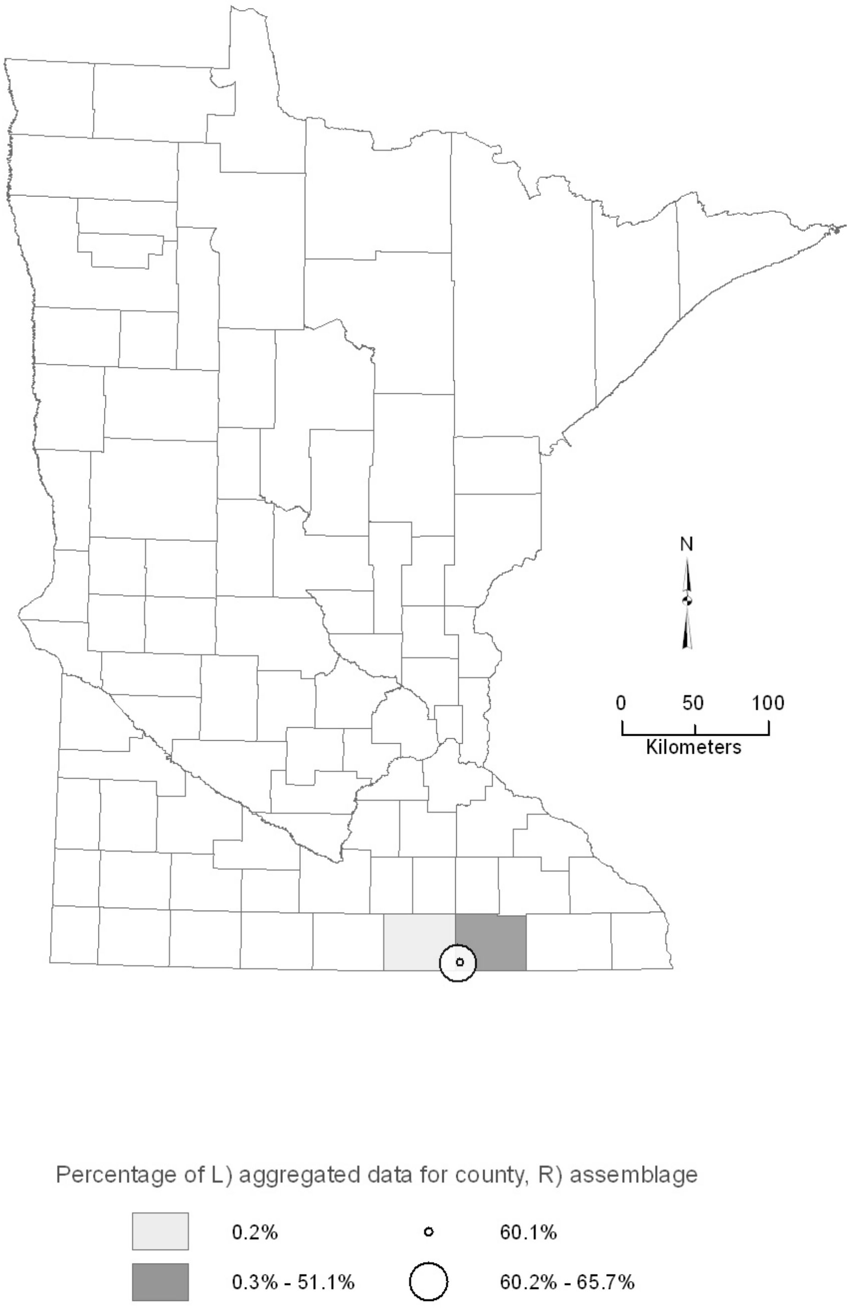
Appendix 1-15. Statewide distribution of Grand Meadow Chert by county and for selected sites.



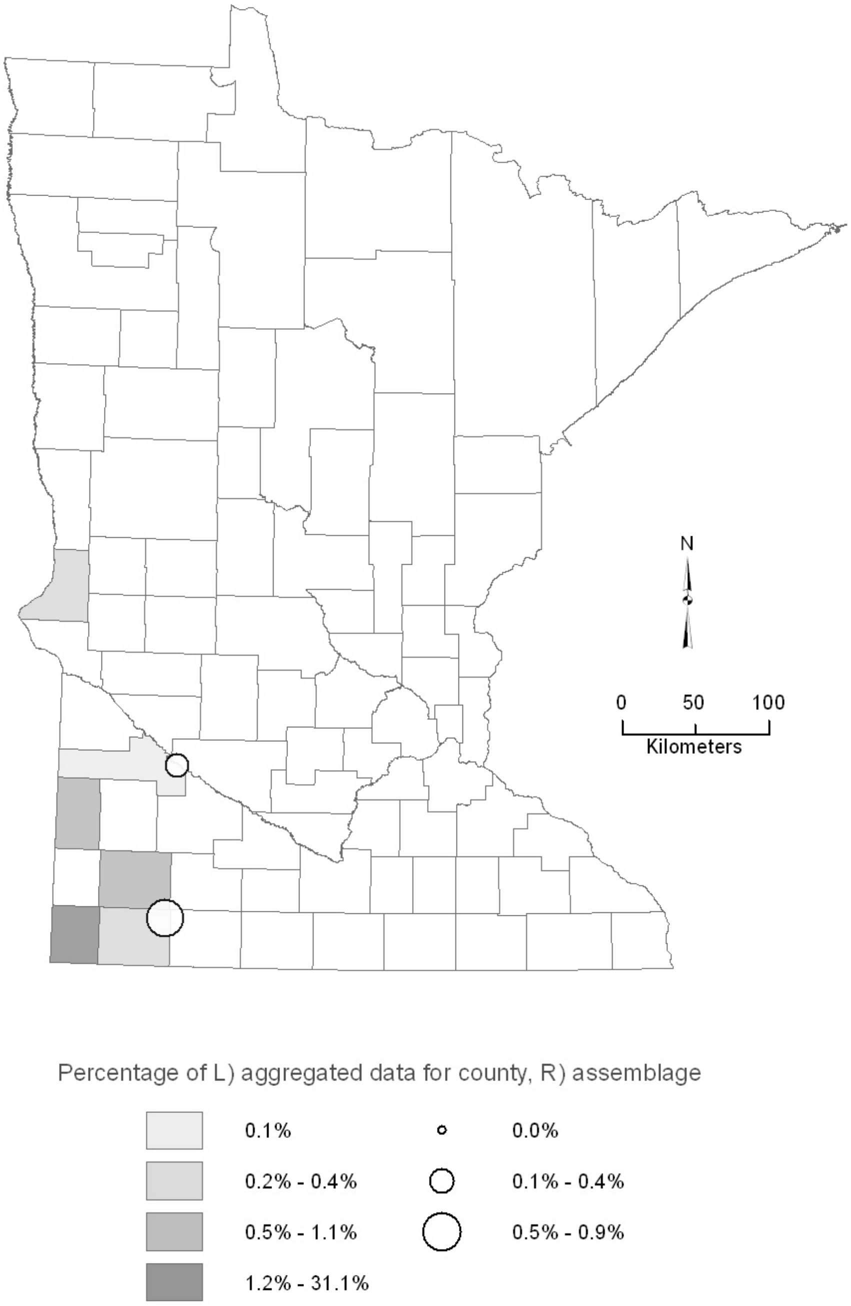
Appendix 1-16. Statewide distribution of Prairie du Chien Chert by county and for selected sites.



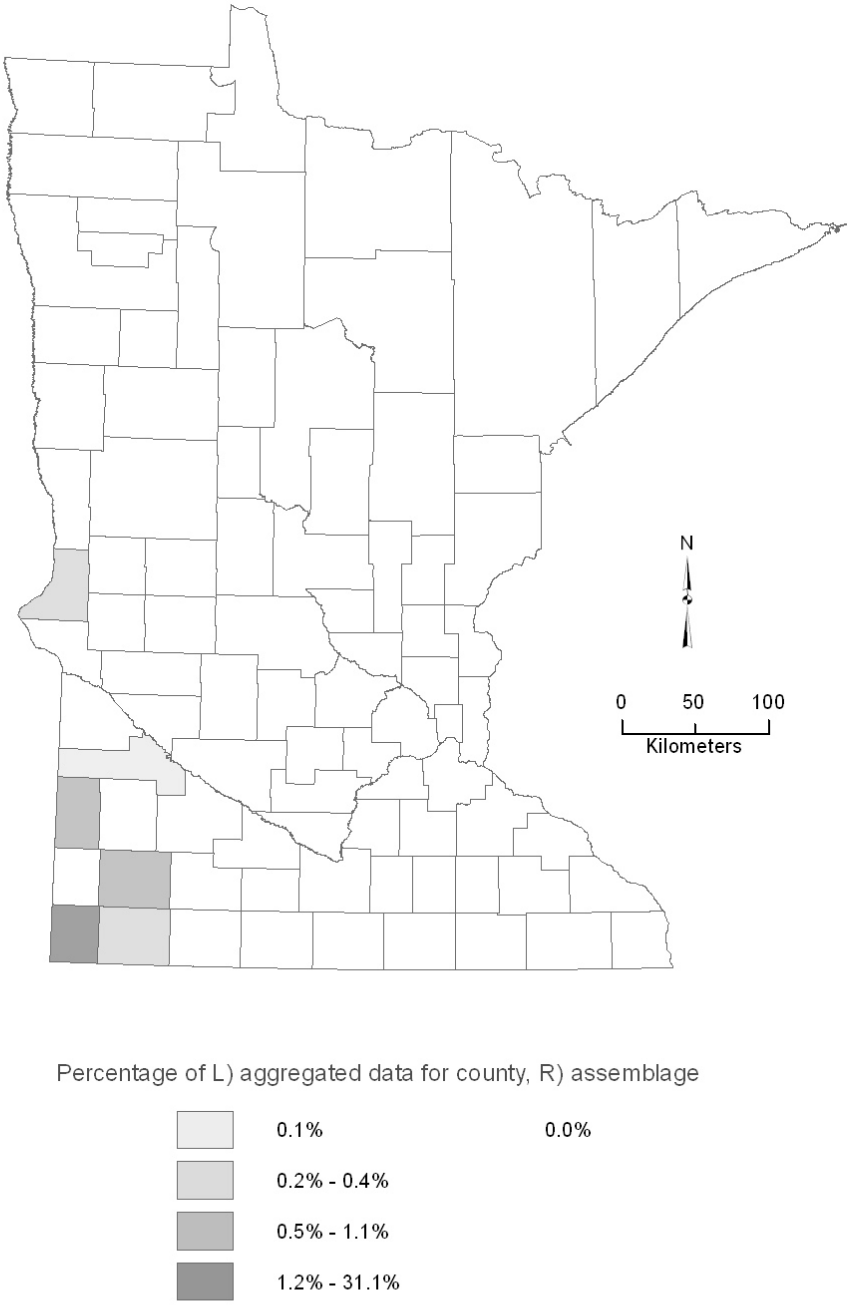
Appendix 1-17. Statewide distribution of Shell Rock Chert by county and for selected sites.



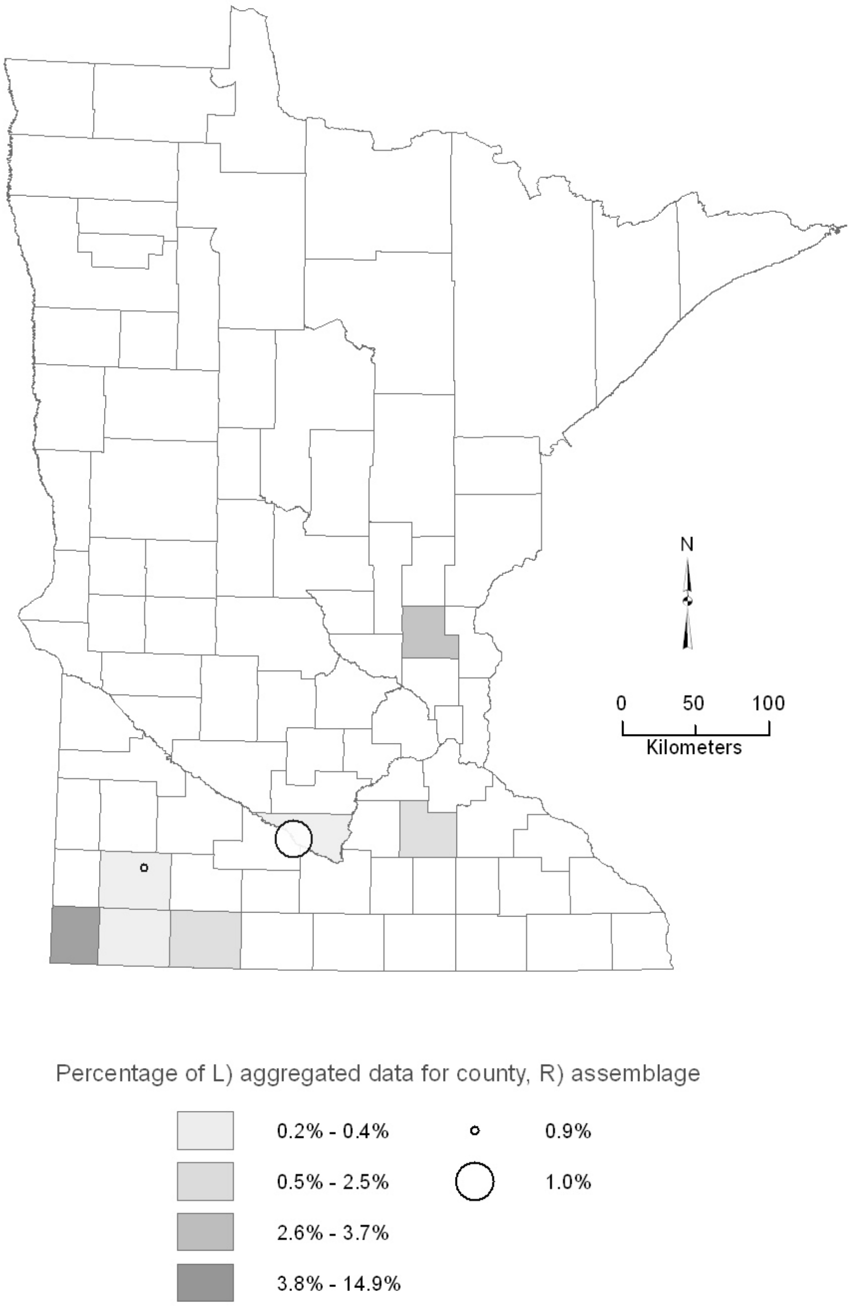
Appendix 1-18. Statewide distribution of Pipestone Resource Region raw materials by county and for selected sites.



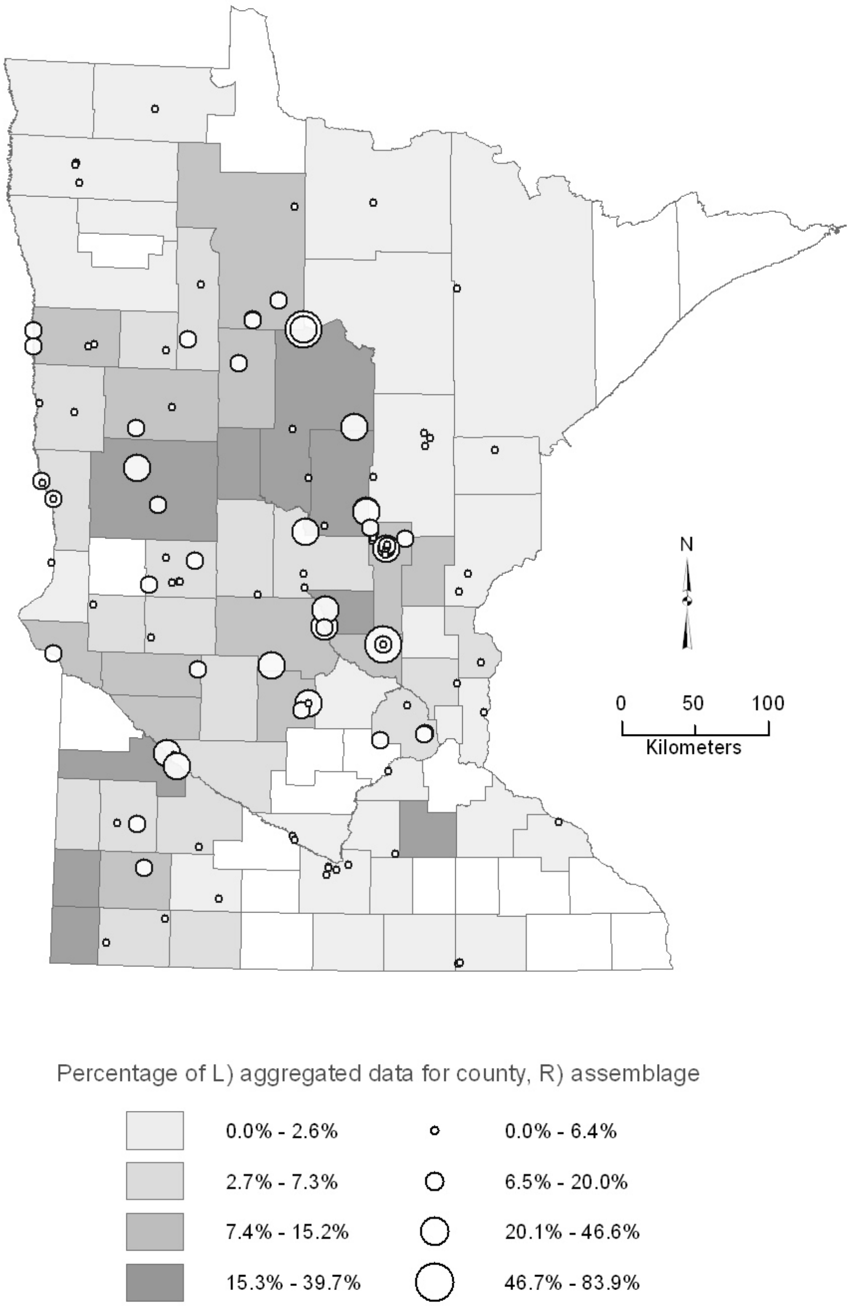
Appendix 1-19. Statewide distribution of Gulseth Silica by county and for selected sites.



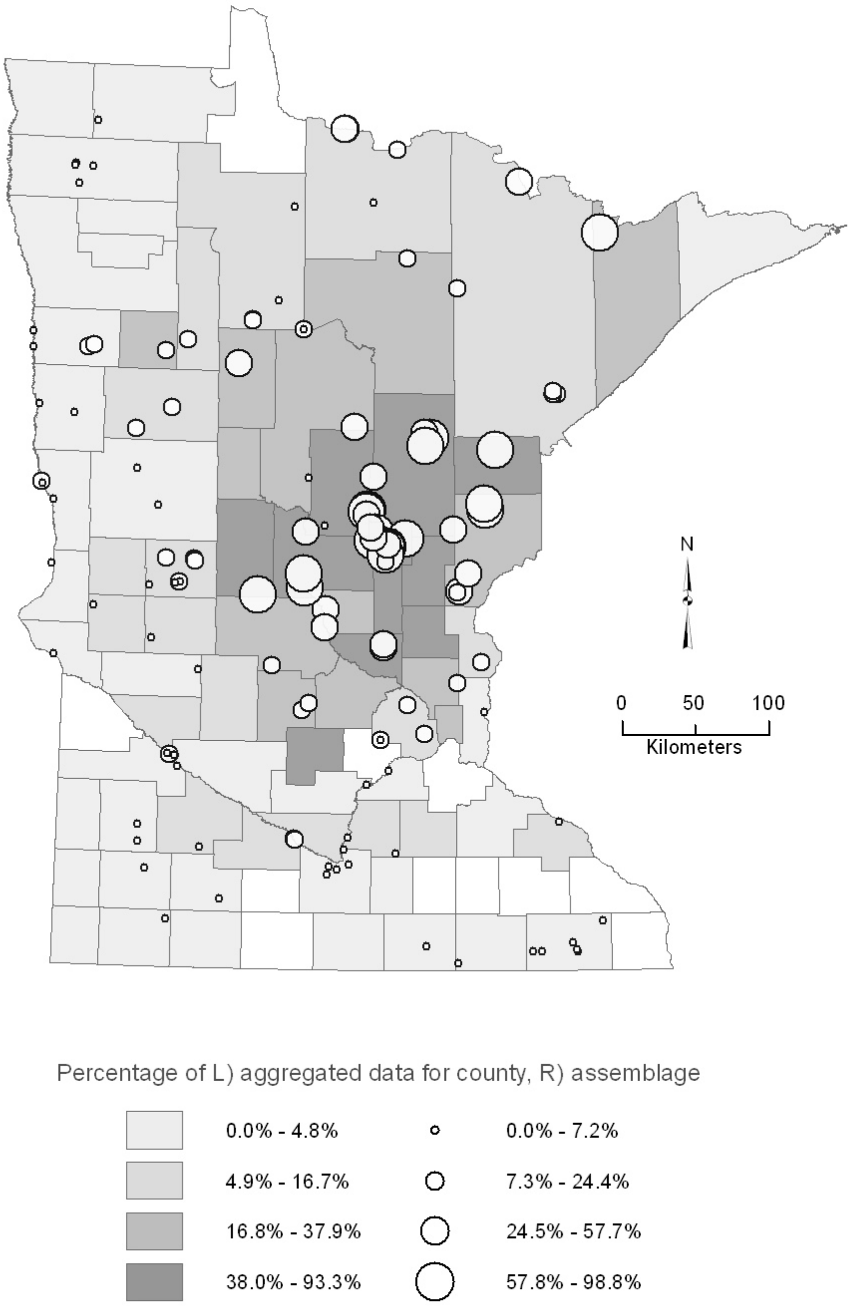
Appendix 1-20. Statewide distribution of Sioux Quartzite Group raw materials by county and for selected sites.



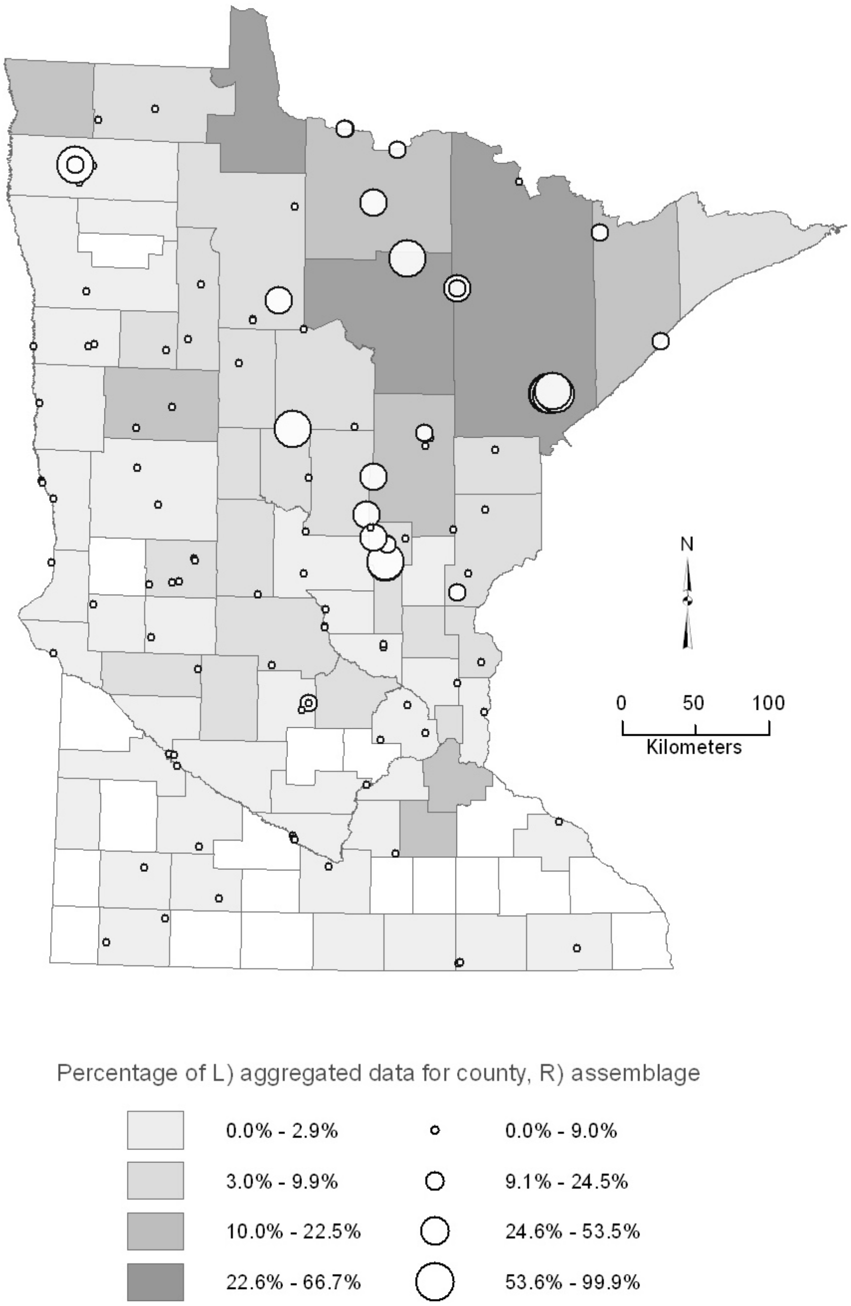
Appendix 1-21. Statewide distribution of Tongue River Silica by county and for selected sites.



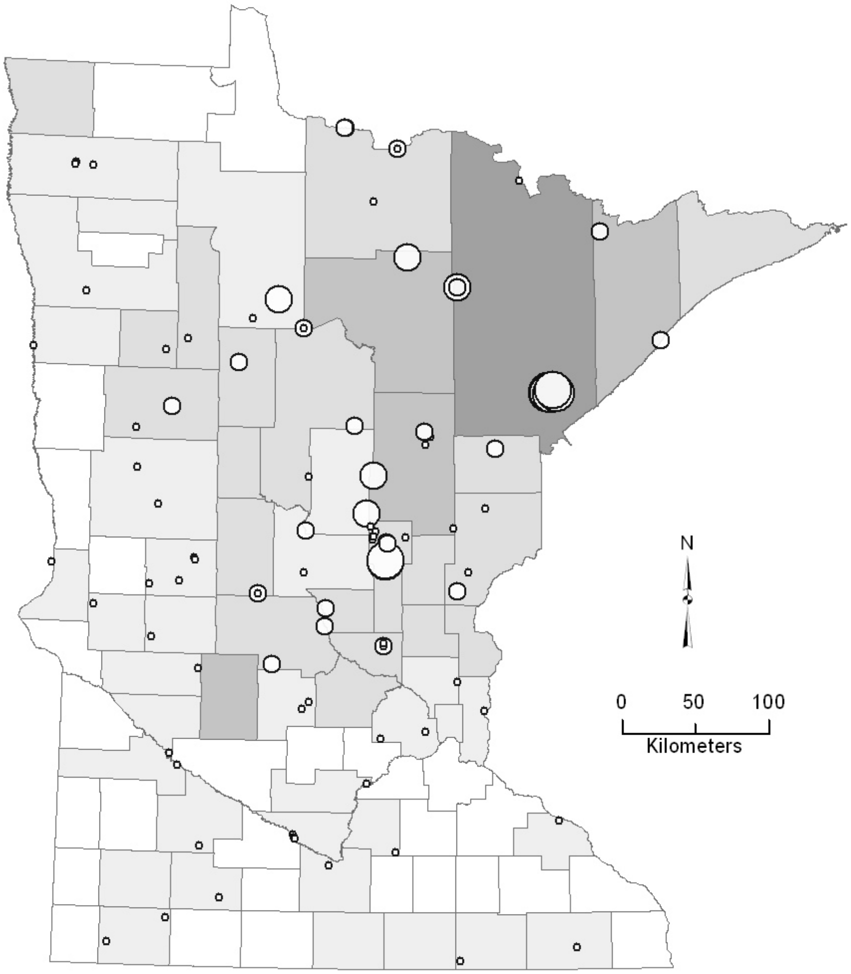
Appendix 1-22. Statewide distribution of quartz by county and for selected sites.



Appendix 1-23. Statewide distribution of Border Lakes Greenstone Group raw materials by county and for selected sites.



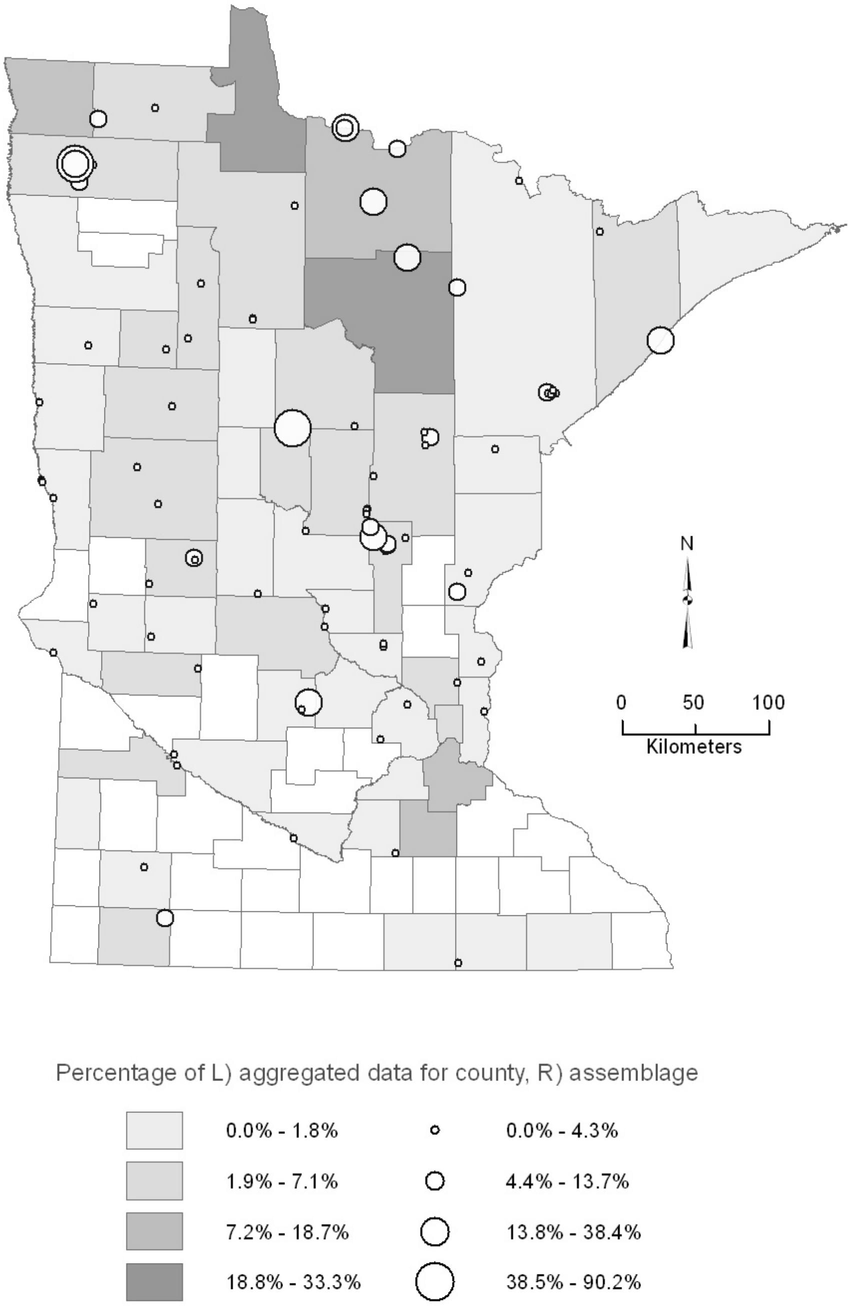
Appendix 1-24. Statewide distribution of Knife Lake Siltstone by county and for selected sites.



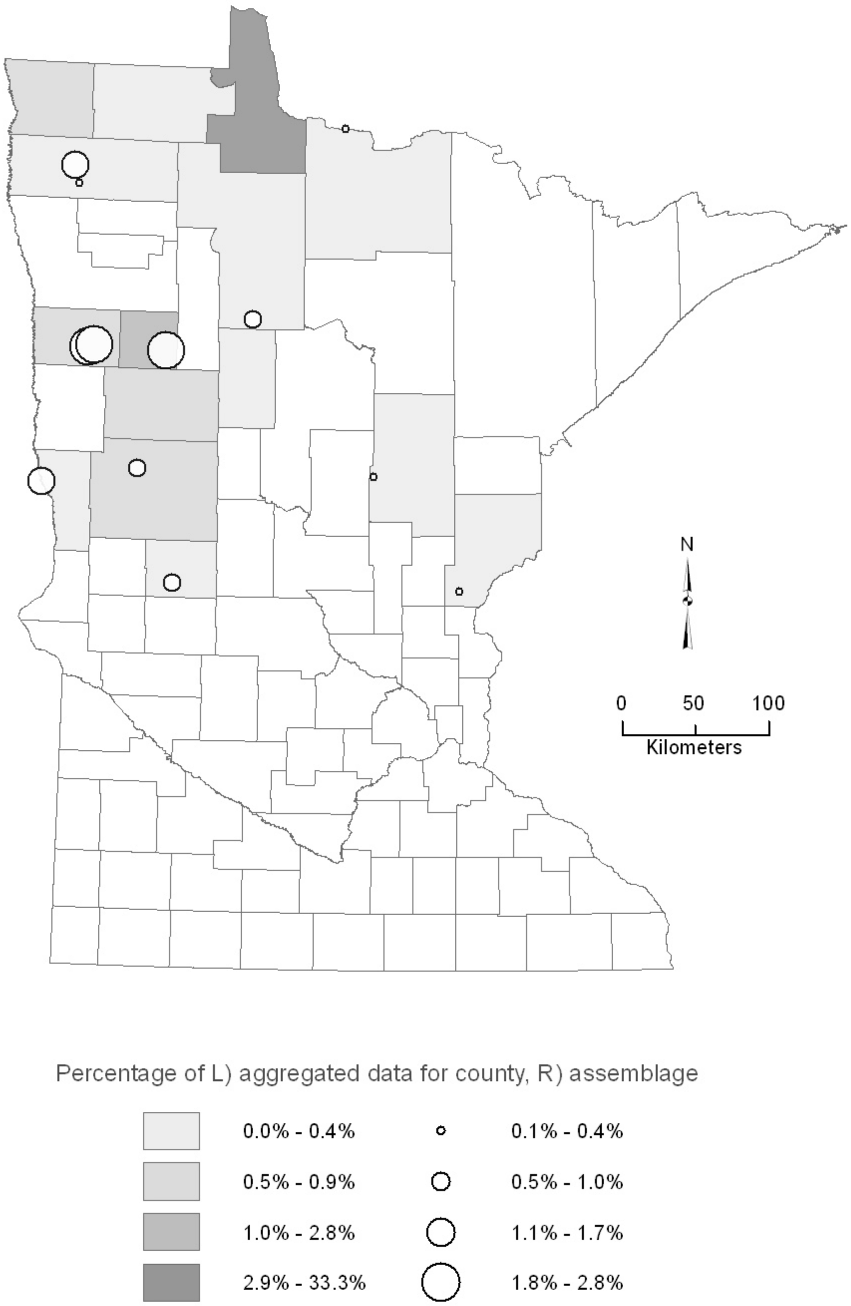
Percentage of L) aggregated data for county, R) assemblage

▢	0.0% - 2.1%	○	0.0% - 4.7%
▢	2.2% - 7.4%	○	4.8% - 16.0%
▨	7.5% - 19.5%	○	16.1% - 51.3%
■	19.6% - 64.4%	○	51.4% - 99.9%

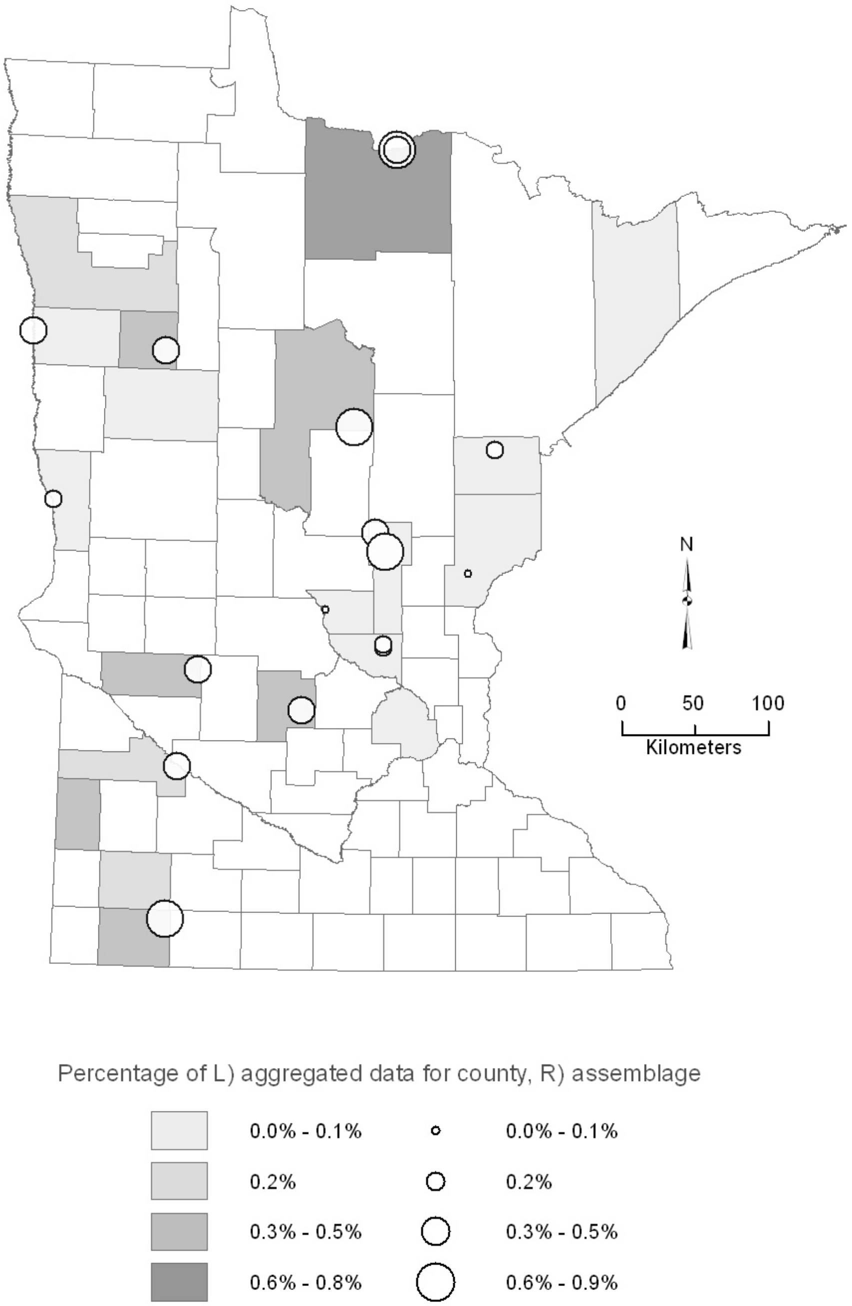
Appendix 1-25. Statewide distribution of Lake of the Woods Rhyolite by county and for selected sites.



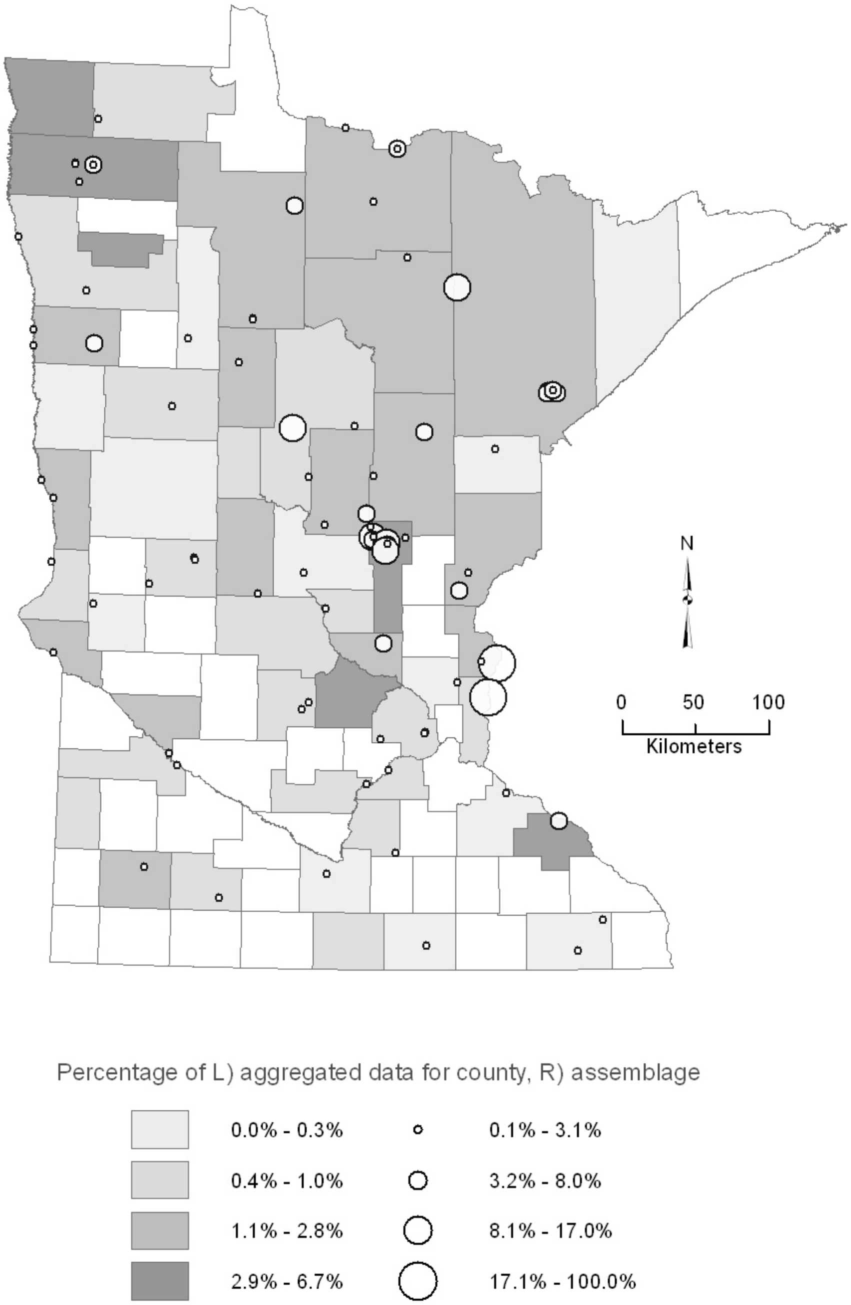
Appendix 1-26. Statewide distribution of Lake of the Woods Siltstone by county and for selected sites.



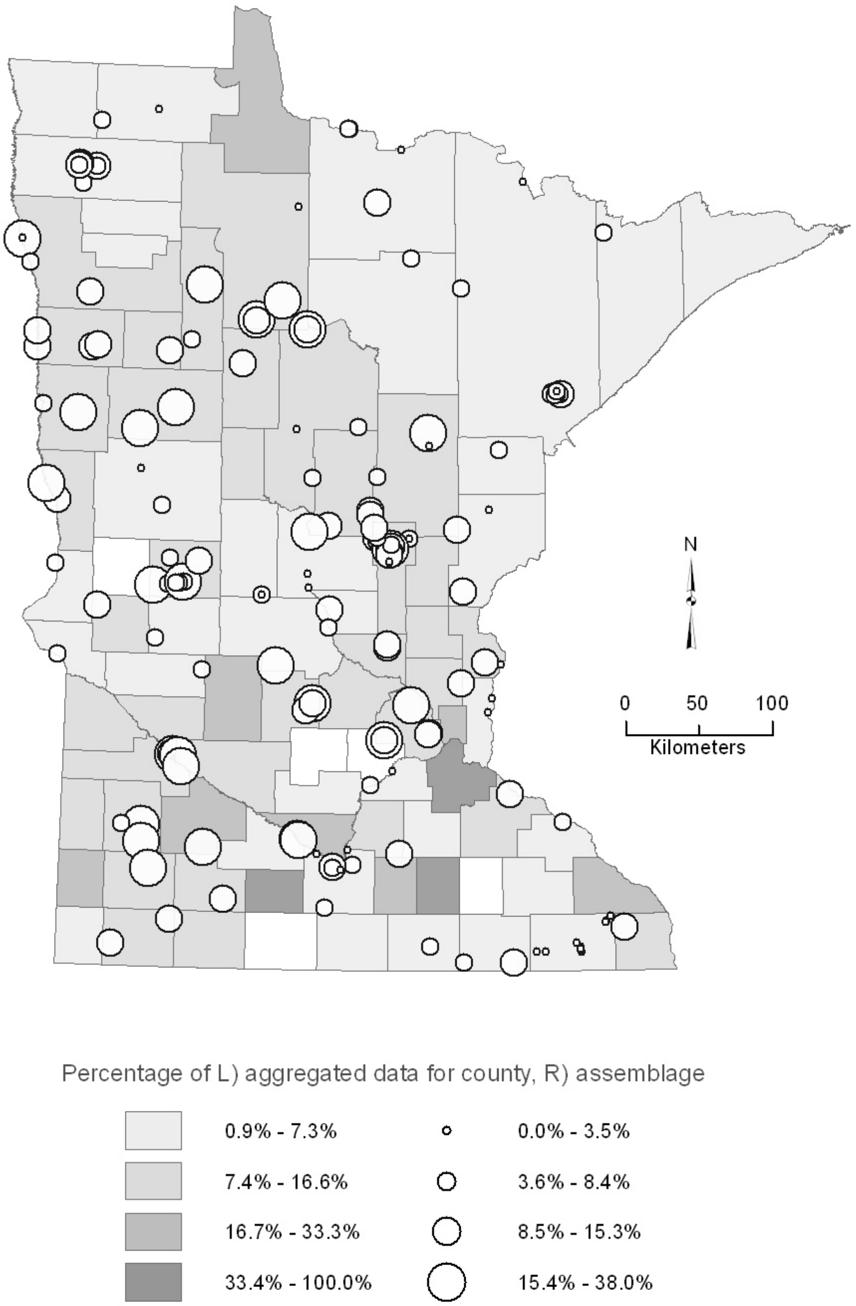
Appendix 1-27. Statewide distribution of Western River Gravels Group raw materials by county and for selected sites.



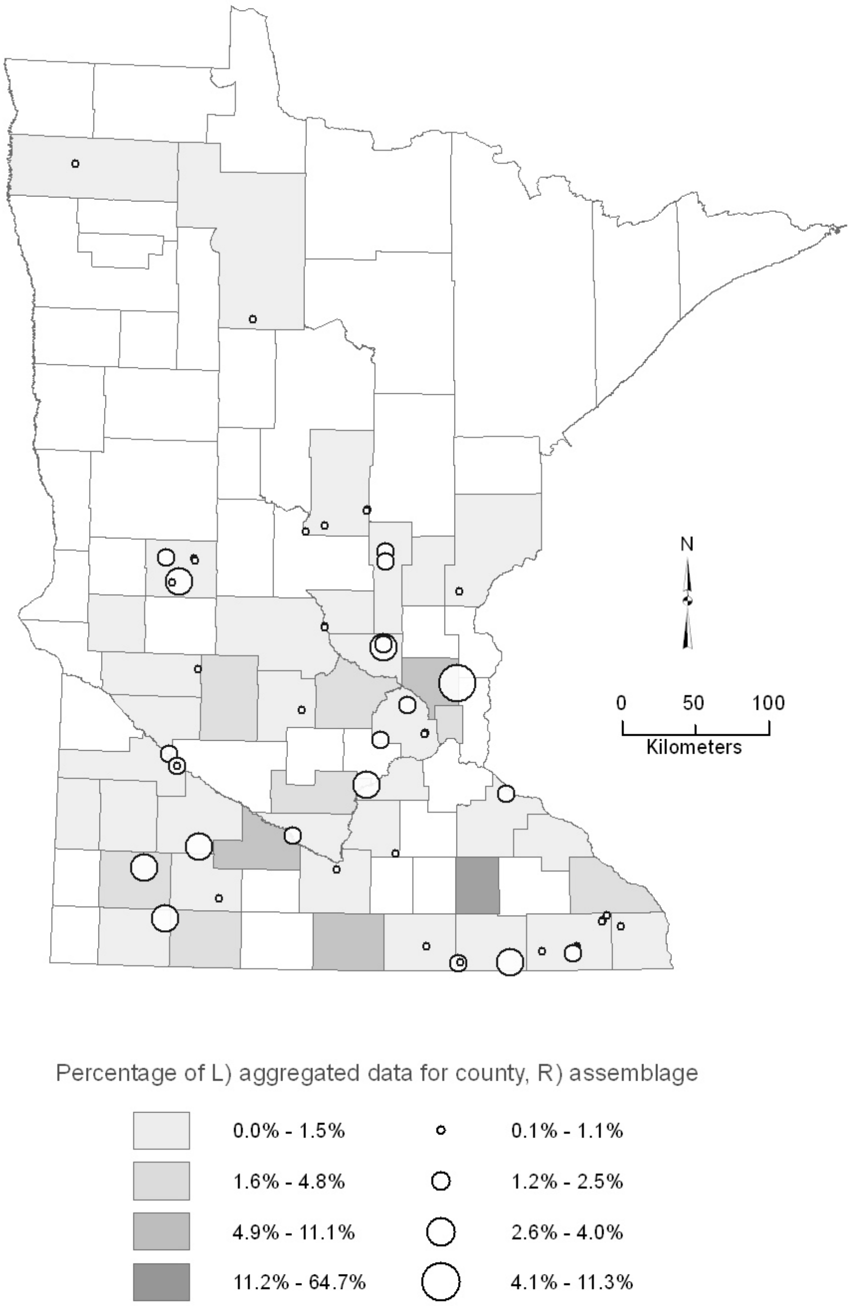
Appendix 1-28. Statewide distribution of raw materials associated with chopping tools by county and for selected sites.



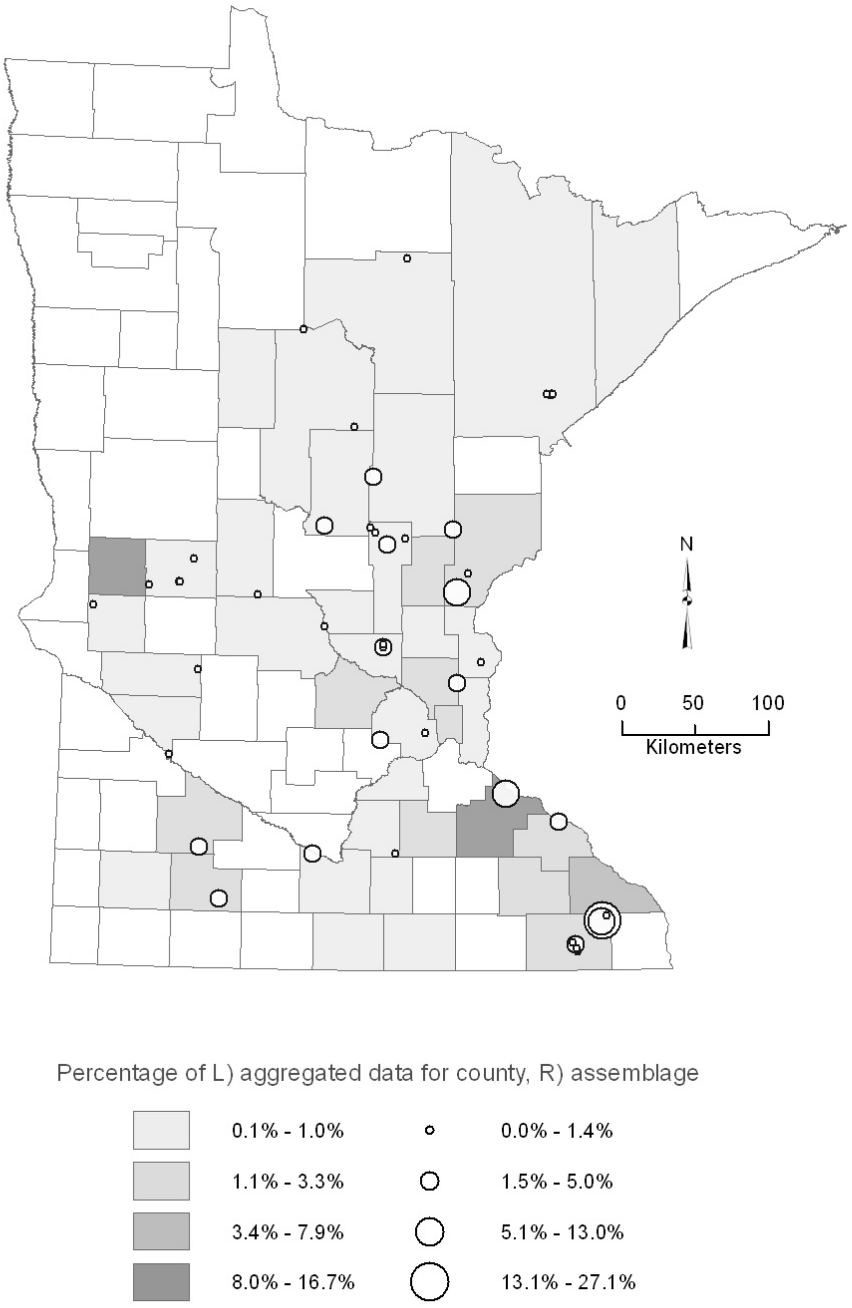
Appendix 1-29. Statewide distribution of unidentified or generically identified raw materials by county and for selected sites.



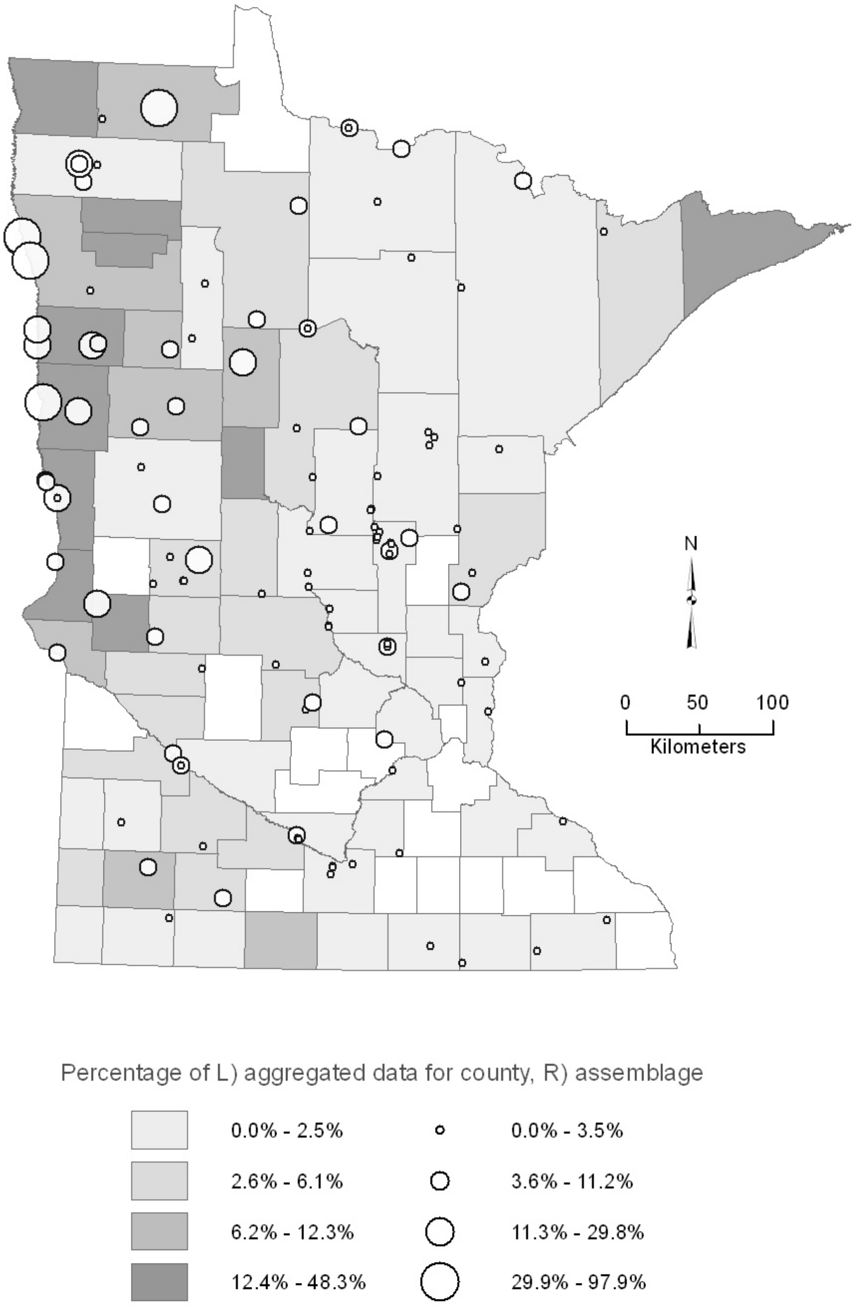
Appendix 1-30. Statewide distribution of Burlington Chert by county and for selected sites.



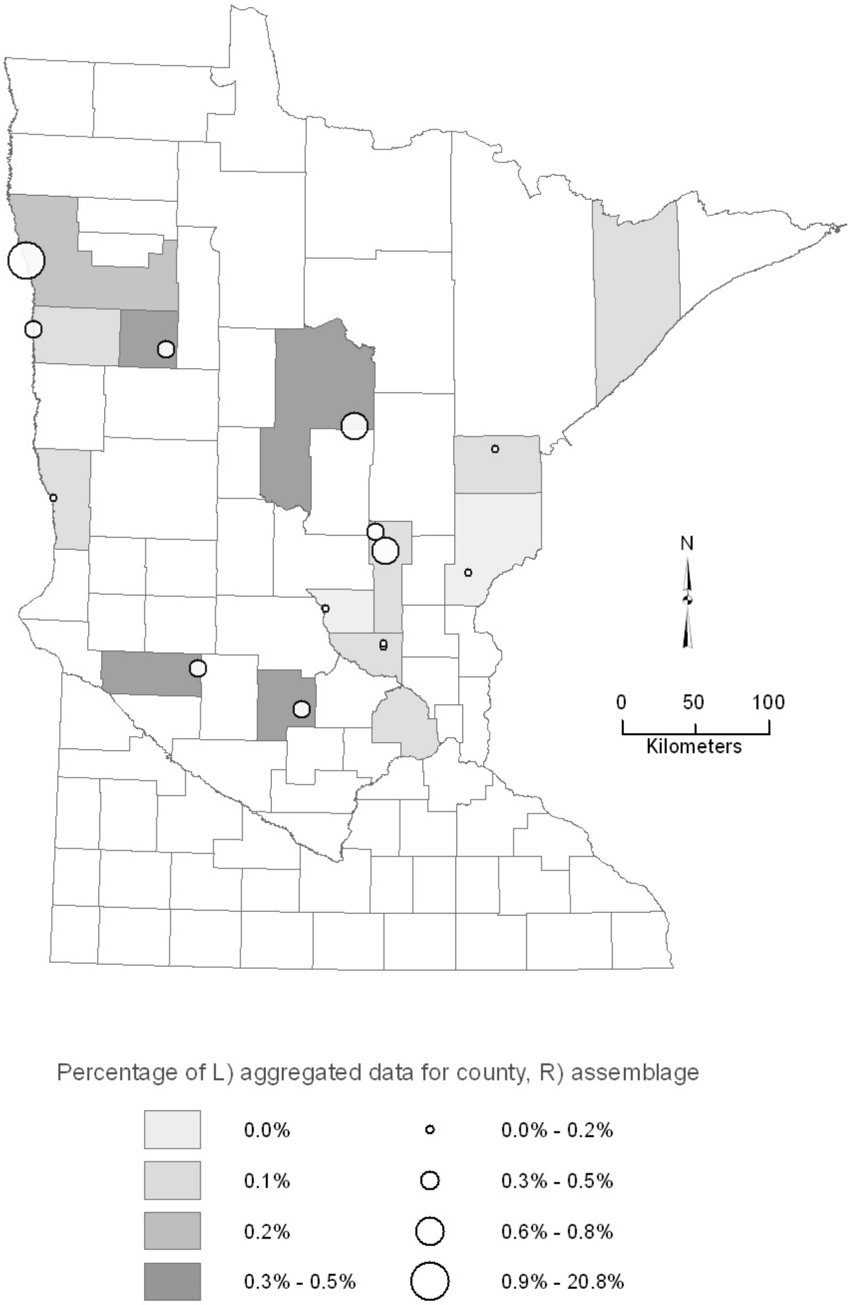
Appendix 1-31. Statewide distribution of Hixton Group raw materials by county and for selected sites.



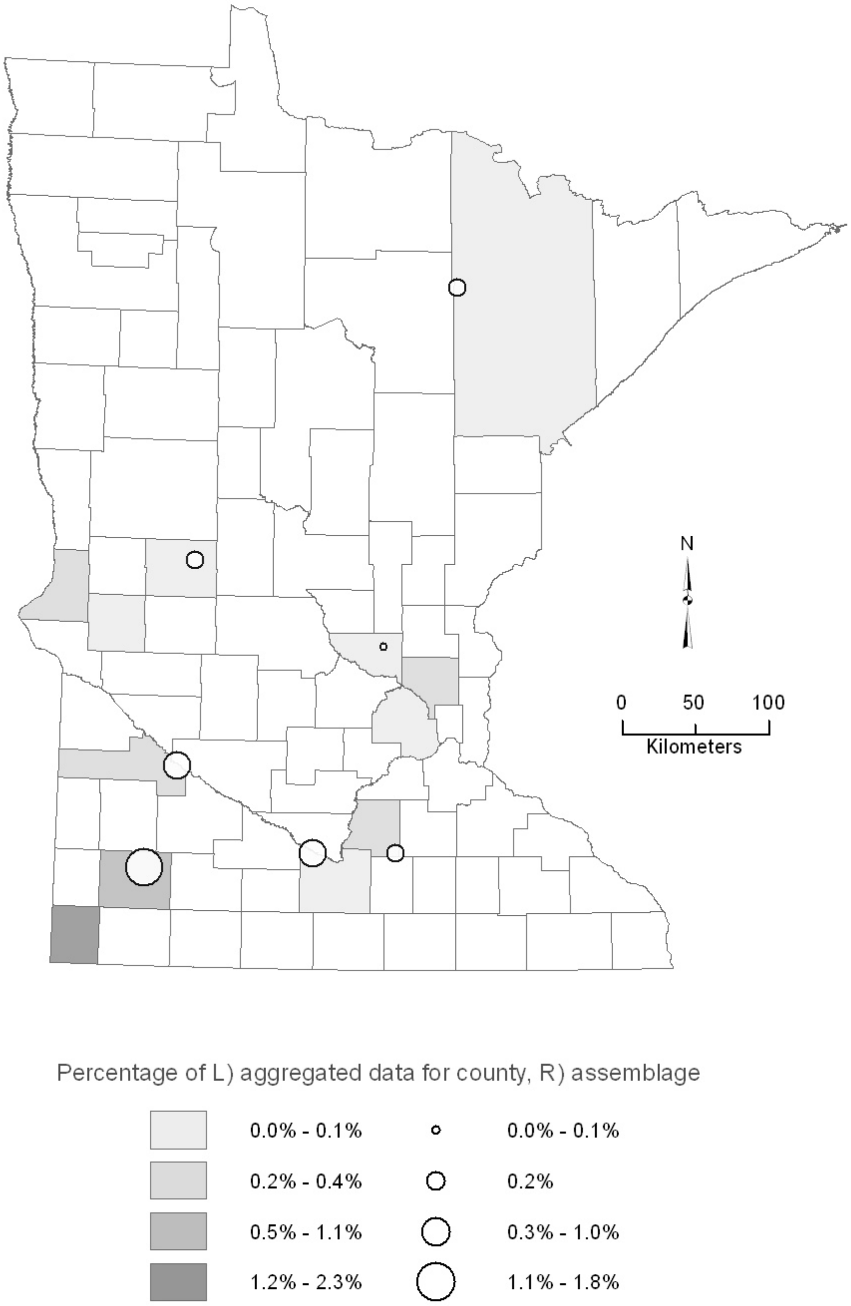
Appendix 1-32. Statewide distribution of Knife River Flint by county and for selected sites.



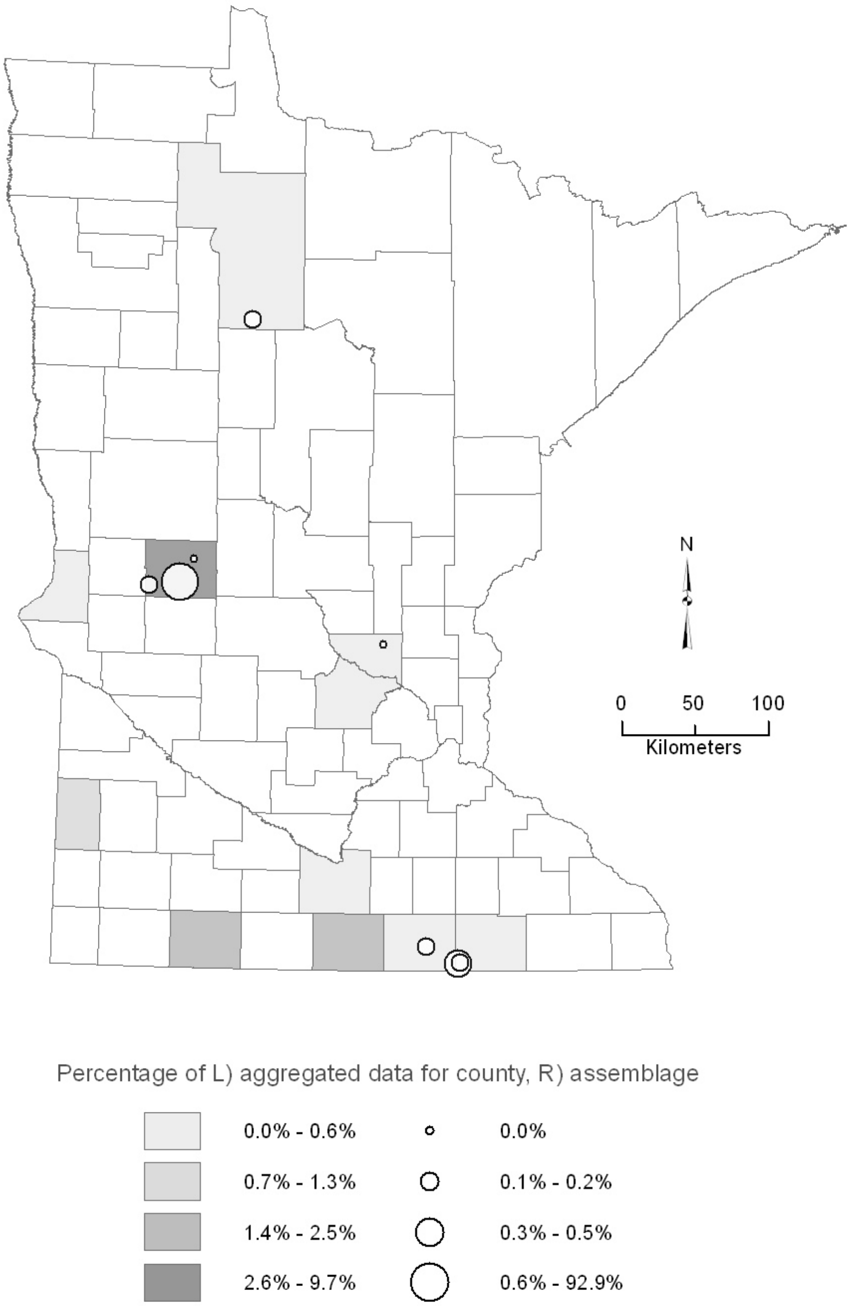
Appendix 1-33. Statewide distribution of obsidian by county and for selected sites.



Appendix 1-34. Statewide distribution of Fusilinid Group cherts by county and for selected sites.



Appendix 1-35. Statewide distribution of Maynes Creek Chert by county and for selected sites.



Appendix 2. Utility analysis XYZ graphs and raw material breakouts for sites discussed in text.

The pages of Appendix 2 are in order by Smithsonian trinomial (United States) and then by Borden number (Canada). Multiple components from one site are presented in chronological order. Series broken out by excavation levels proceed from lowest to highest levels (i.e., in chronological order).

Each page includes an indication of the diversity of each assemblage, or in other words the number of different raw materials in the assemblage. Note that this count is often larger than the number of raw materials or categories in the associated utility plane breakout table. This is because the utility plane breakout table includes categories that can subsume more than one raw material. The "unidentified" category, for example, might cover generically identified artifacts (e.g., chalcedony, chert, jasper, etc.), or artifacts of raw materials not yet located in the utility plane (e.g., Fort Union Porcellanite, Gulseth Silica, Moline Chert).

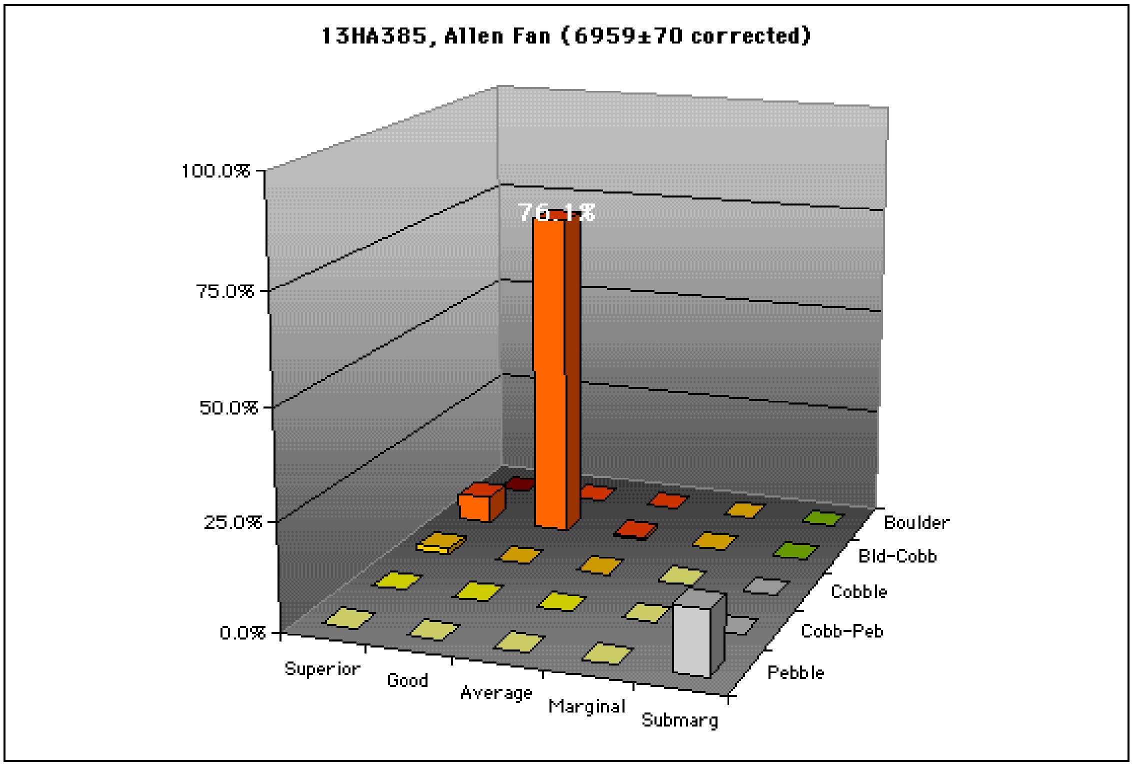
Raw material abbreviations used in the utility plane breakout tables.

Abbrev.	Raw Material	Abbrev.	Raw Material
Amk Grp	Animikie Group	LoWR	Lake of the Woods Rhyolite
CVC	Cedar Valley Chert	LoWS	Lake of the Woods Siltstone
Fusil Grp	Fusilinid Group	LSA	Lake Superior Agate
GFS	Gunflint Silica	Myns Crk	Maynes Creek Chert
GMC	Grand Meadow Chert	nID	Unidentified
HBL[C]	Hudson Bay Lowland Chert	PdC	Prairie du Chien Chert
Jasp Tac	Jasper Taconite	RRC	Red River Chert
KLS	Knife Lake Siltstone	SRC	Swan River Chert
KRF	Knife River Flint	TRS	Tongue River Silica

Key to use pattern abbreviations.

Key	Use Pattern	Key	Use Pattern
B	Boulder Core	P	Pebble Core
C	Cobble Core	S	Strategic Source

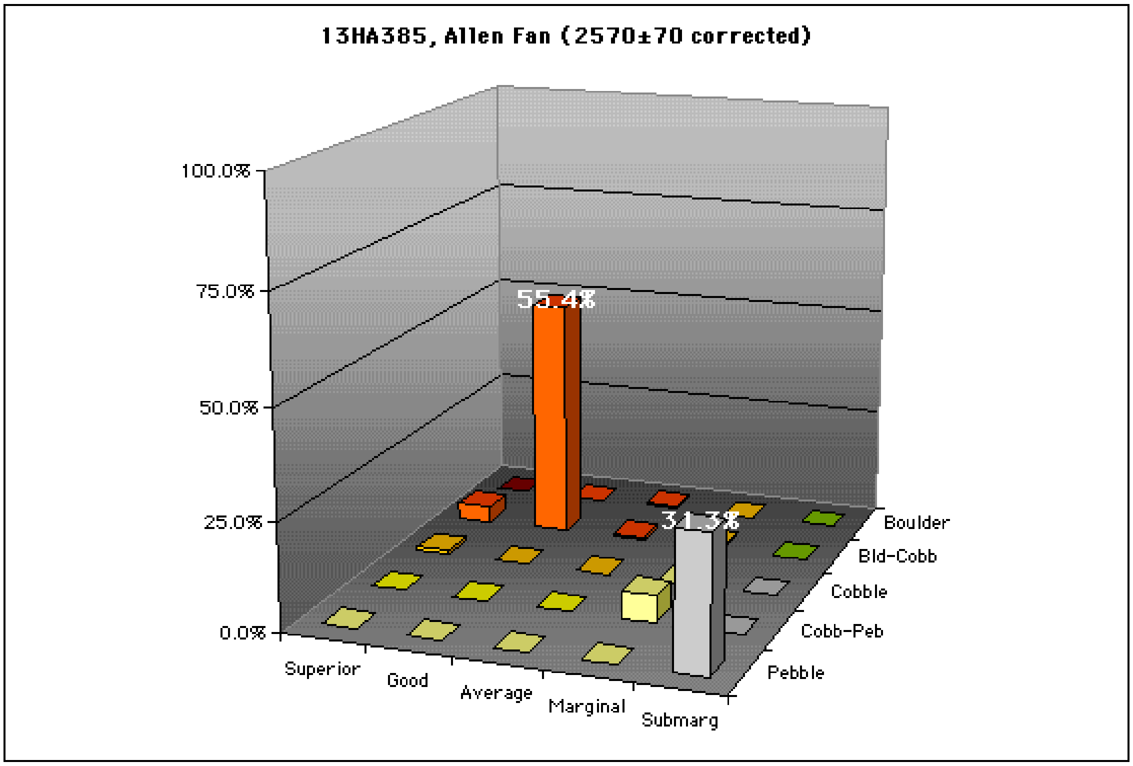
Appendix 2. 13HA385, Allen Fan (Early Archaic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	Burlington 6.2	CVC 6.8 Galena 3.6 Myns Crk 65.4	PdC 0.7	TRS 0.1	
Cobble	GMC 1.4	Fusil Grp 0.1			
Cobble-Pebble				Quartz 0.2	
Pebble					nID 15.0

Region / Sub	South Agassiz / Shetek; Hollandale	**Sample Size**	5,230
Component	Early Archaic	**Diversity**	15
Reference	Fishel 2003a, 2003b; Fishel and Collins 2003	**Use Pattern**	C

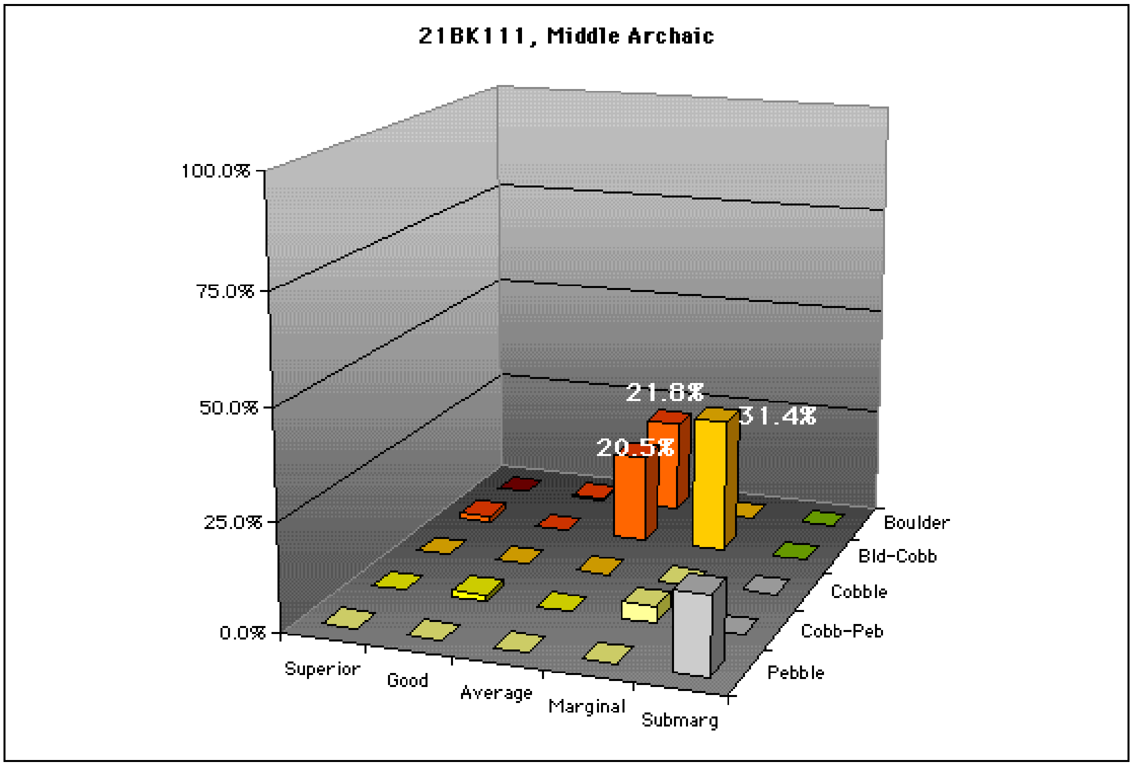
Appendix 2. 13HA385, Allen Fan (Late Archaic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 0.2 KLS 0.2		
Boulder-Cobble	Burlington 3.9	CVC 1.4 Galena 1.7 Myns Crk 52.3	PdC 0.7	TRS 1.0	
Cobble	GMC 1.0				
Cobble-Pebble				Quartz 6.3	
Pebble					nID 31.3

Region / Sub	South Agassiz / Shetek; Hollandale	**Sample Size**	414
Component	Late Archaic	**Diversity**	14
Reference	Fishel 2003a, 2003b; Fishel and Collins 2003	**Use Pattern**	C

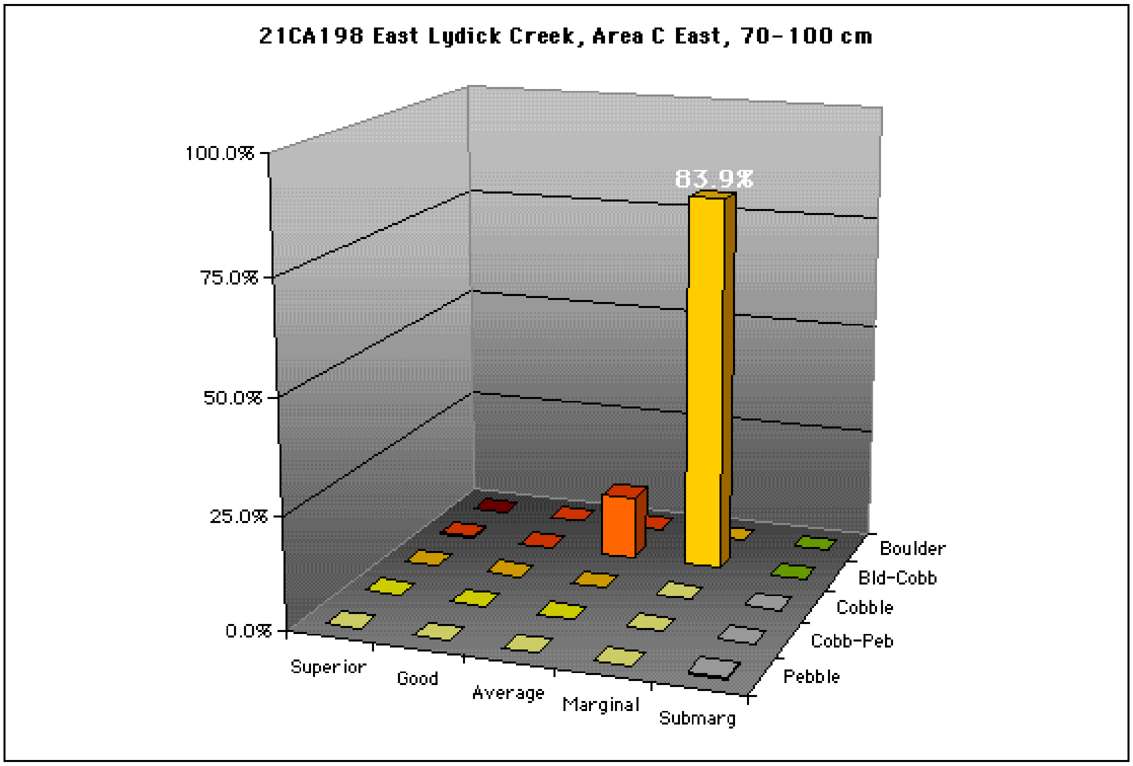
Appendix 2. 21BK111.



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 0..6	KLS 4.5 LoWR 17.2		
Boulder-Cobble	KRF 1.5		SRC 20.2 PdC 0.3	TRS 31.4	
Cobble					Granitic 0.3
Cobble-Pebble		RRC 1.5		Quartz 3.9	
Pebble				LSA 0.3	nID 18.1

Region / Sub	South Agassiz / Upper Red	**Sample Size**	331
Component	Middle Archaic	**Diversity**	14
Reference	Florin 2006	**Use Pattern**	C

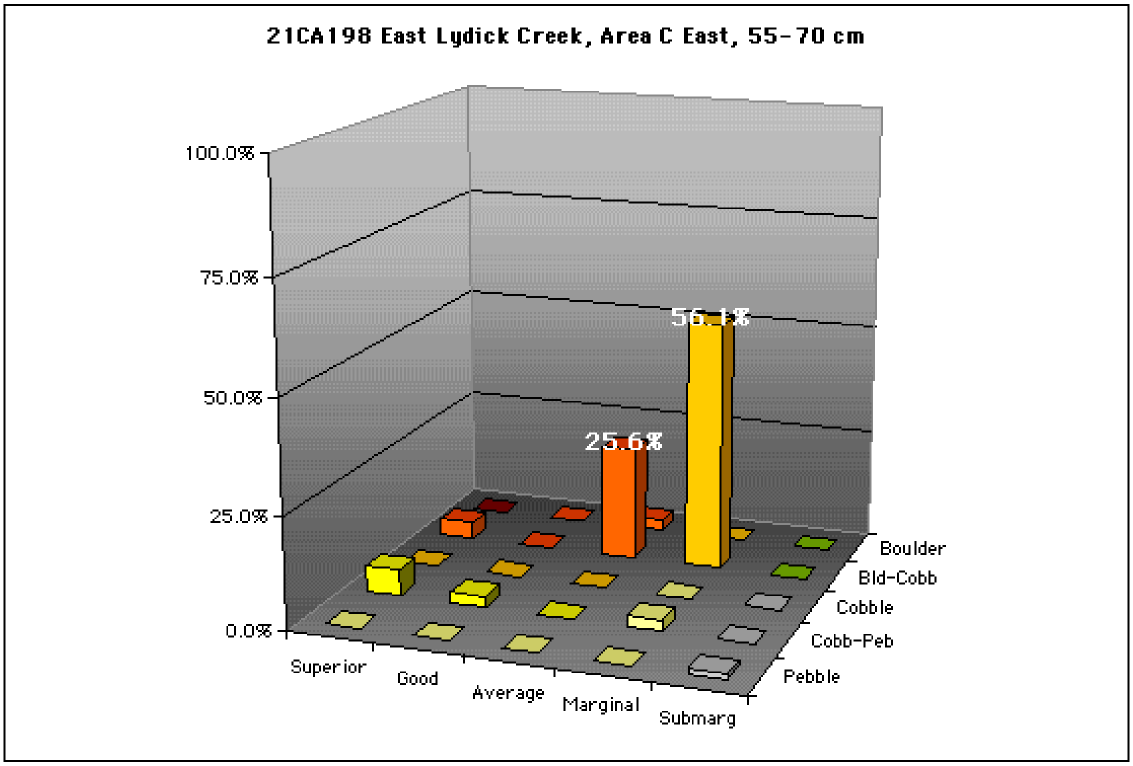
Appendix 2. 21CA198, East Lydick Creek, Area C East, 70-100 cm (lower component).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 0.3		
Boulder-Cobble	KRF 0.3		SRC 14.3	TRS 83.9	
Cobble					
Cobble-Pebble	HBLC 0.3	RRC 0.3			
Pebble					nID 0.6

Region / Sub	West Superior / Quartz	**Sample Size**	342
Component		**Diversity**	7
Reference	Emerson 1996	**Use Pattern**	C

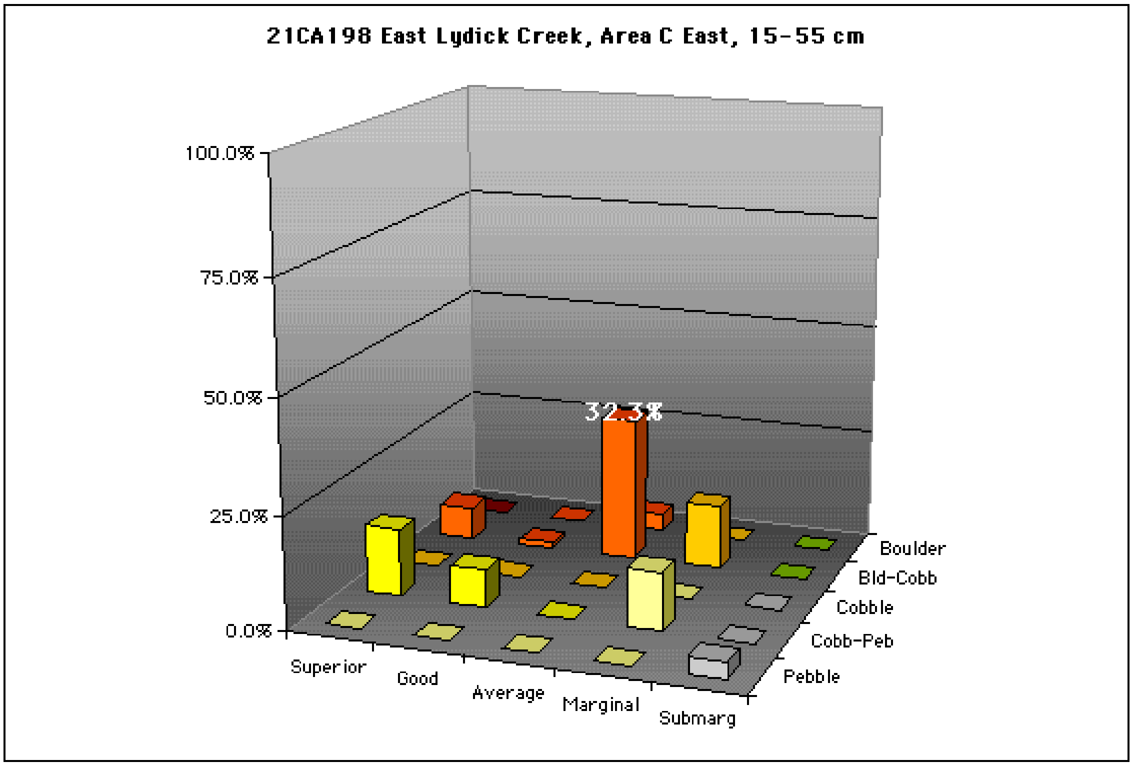
Appendix 2. 21CA198, East Lydick Creek, Area C East, 55-70 cm (mixed components).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 1.7		
Boulder-Cobble	KRF 3.3		SRC 23.1	TRS 57.9	
Cobble					
Cobble-Pebble	HBLC 6.6	RRC 3.3		Quartz 1.7	
Pebble					nID 2.5

Region / Sub	West Superior / Quartz	**Sample Size**	121
Component		**Diversity**	**9**
Reference	Emerson 1996	**Use Pattern**	C+P

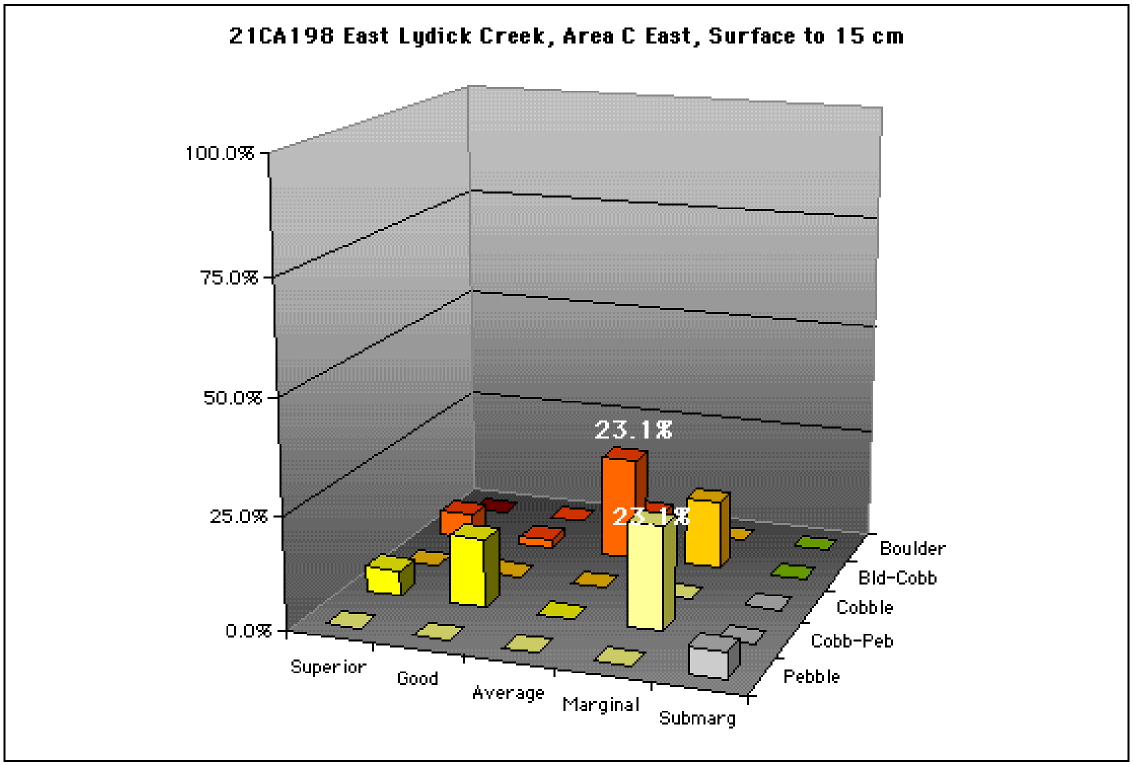
Appendix 2. 21CA198, East Lydick Creek, Area C East, 15-55 cm (upper component).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 0.7 KLS 3.2		
Boulder-Cobble	KRF 7.4	GFS 1.4	SRC 32.3	TRS 14.5	
Cobble					
Cobble-Pebble	HBLC 15.2	RRC 8.6		Quartz 12.8	
Pebble					nID 3.8

Region / Sub	West Superior / Quartz	**Sample Size**	873
Component		**Diversity**	11
Reference	Emerson 1996	**Use Pattern**	P

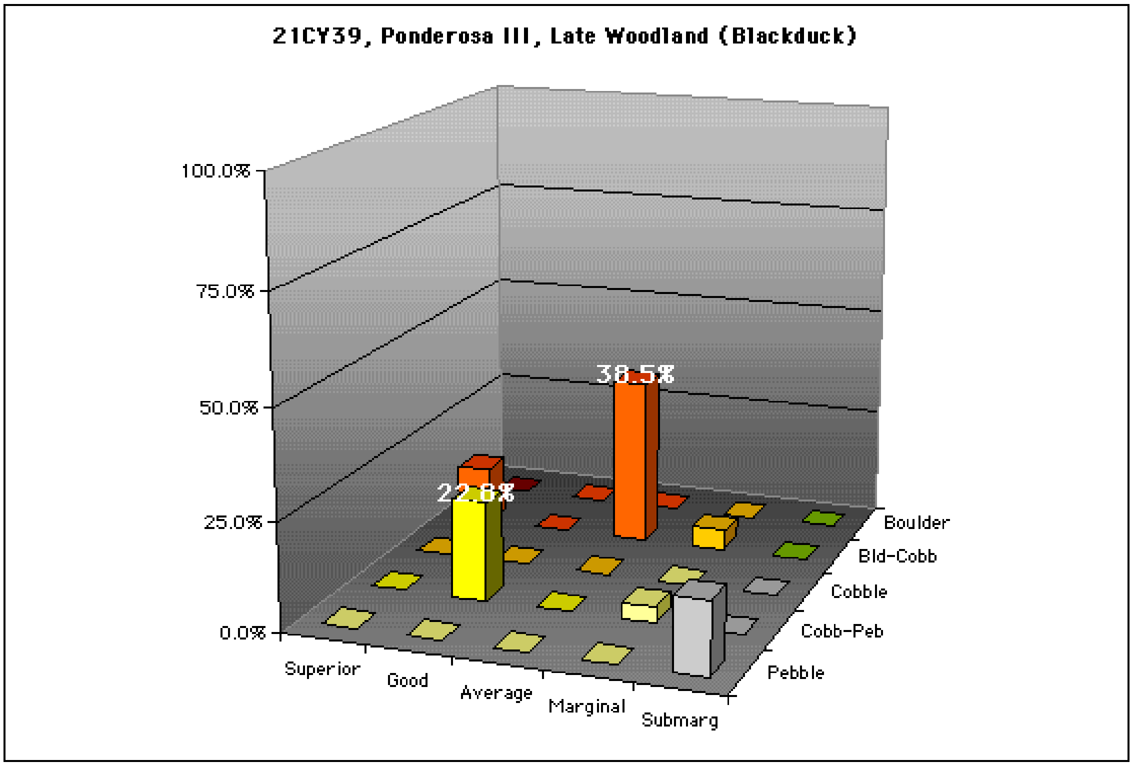
Appendix 2. 21CA198, East Lydick Creek, Area C East, Surface to 15 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 3.8		
Boulder-Cobble	KRF 5.8	GFS 1.9	SRC 23.1	TRS 15.4	
Cobble					
Cobble-Pebble	HBLC 5.8	RRC 15.4		Quartz 23.1	
Pebble					nID 5.8

Region / Sub	West Superior / Quartz	**Sample Size**	52
Component		**Diversity**	10
Reference	Emerson 1996	**Use Pattern**	P

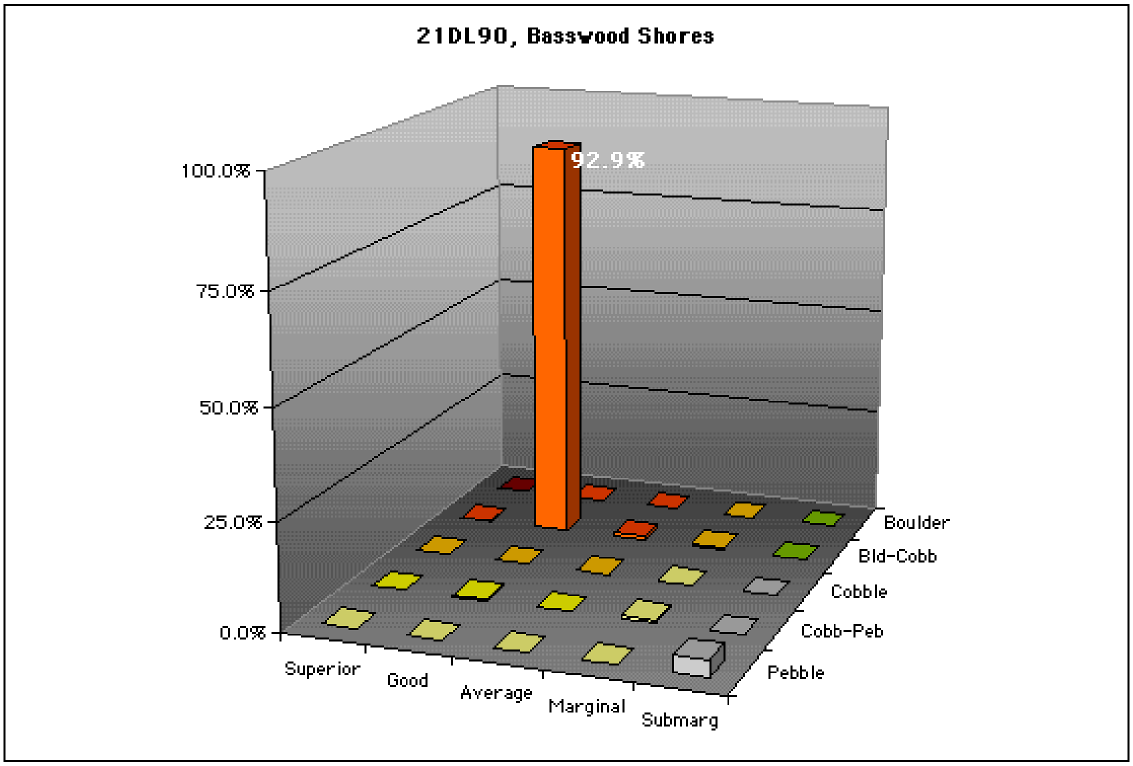
Appendix 2. 21CY39, Ponderosa III (Late Woodland -- Blackduck).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 13.3		SRC 38.5	TRS 4.8	
Cobble					
Cobble-Pebble		RRC 22.8		Quartz 3.8	
Pebble					nID 16.8

Region / Sub	South Agassiz / Upper Red	**Sample Size**	1,292
Component	Late Woodland (Blackduck)	**Diversity**	8
Reference	Michlovic 2005	**Use Pattern**	P

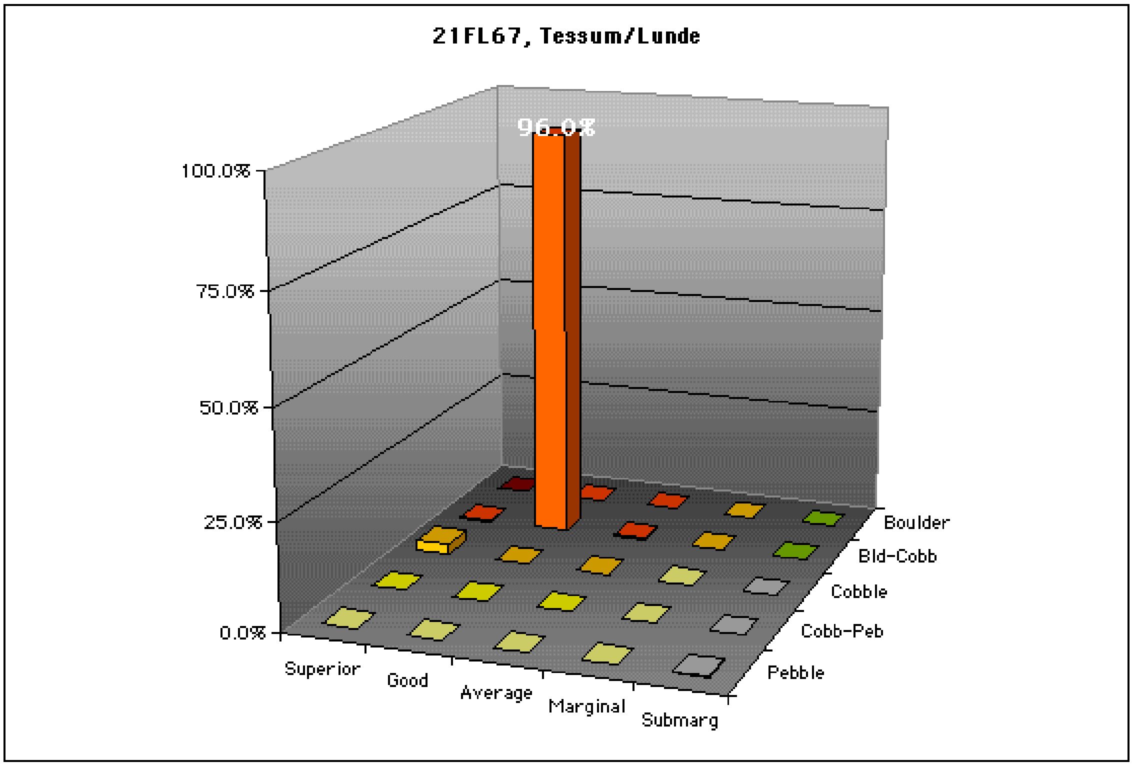
Appendix 2. 21DL90, Basswood Shores.



	Superior	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder			Hixton Grp 0.1		
Boulder-Cobble	KRF 0.1	Myns Crk 92.9	SRC 0.8 PdC 0.2	TRS 0.6	
Cobble	GMC 0.2				
Cobble-Pebble		RRC 0.4		Quartz 0.8	
Pebble					nID 3.9

Region / Sub	South Agassiz / Upper Red	**Sample Size**	902
Component	Woodland (late prehistoric)	**Diversity**	11
Reference	Justin and Schuster 1994	**Use Pattern**	P?

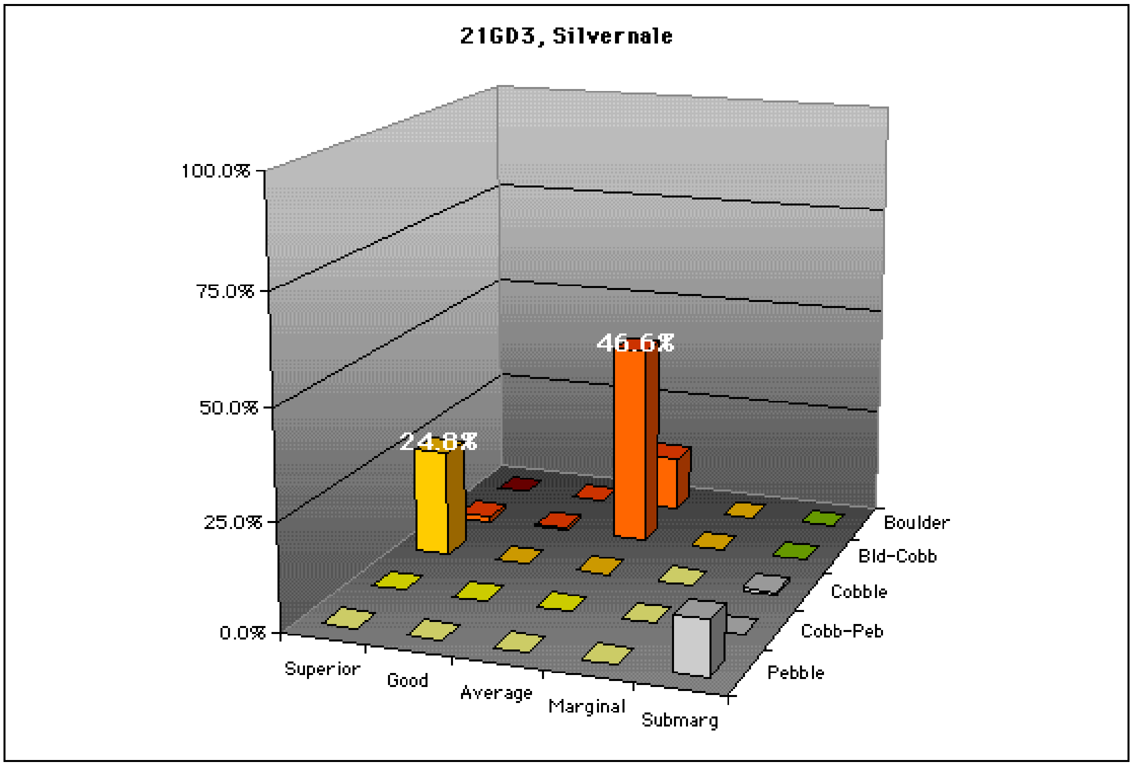
Appendix 2. 21FL67, Tessum / Lunde.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder			Hixton Grp 0.3		
Boulder-Cobble	Burlington 0.3	CVC 5.0 Galena 91.0	PdC 0.5		
Cobble	GMC 2.6				
Cobble-Pebble					
Pebble					nID 0.3

Region / Sub	Hollandale	**Sample Size**	379
Component	Paleoindian	**Diversity**	7
Reference	Gonsior et al. 1994; Myster 1996	**Use Pattern**	B

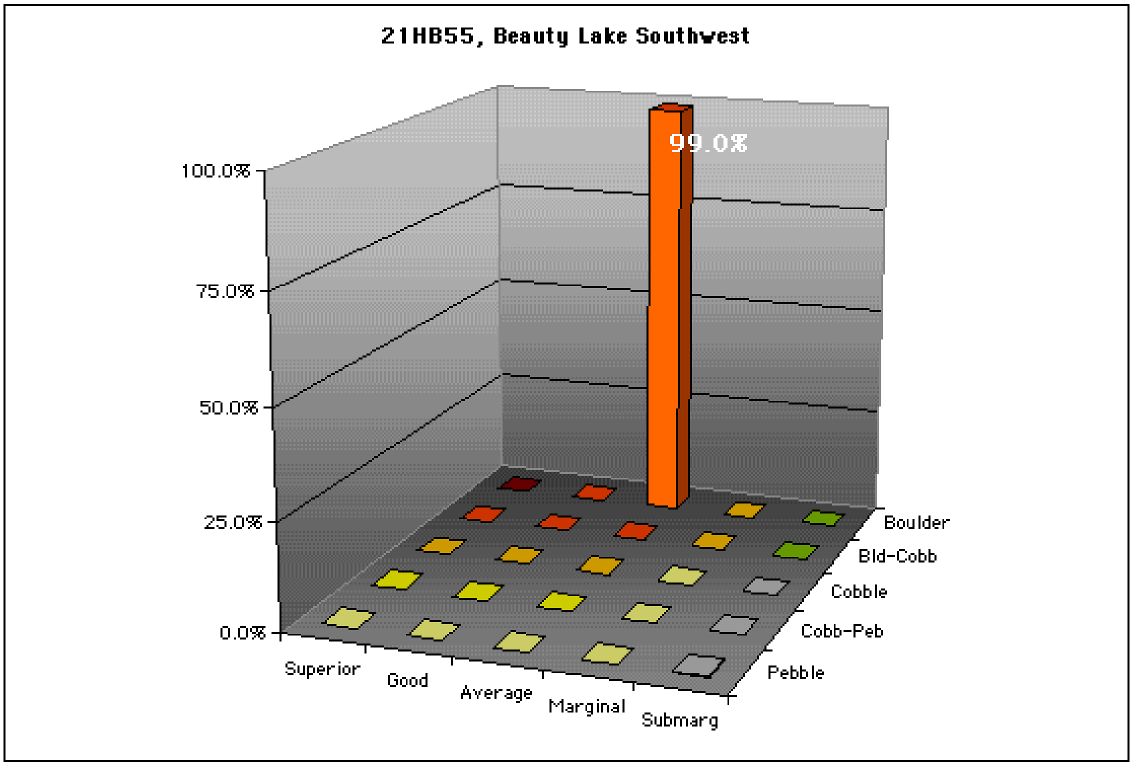
Appendix 2. 21GD3, Silvernale.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 13.0		
Boulder-Cobble	Burlington 1.3	GFS < 0.1 CVC 0.7	PdC 46.6		
Cobble	GMC 24.8				Makoqueta 0.7 Basaltic 0.1
Cobble-Pebble					
Pebble					nID 12.7

Region / Sub	Hollandale	**Sample Size**	3,351
Component		**Diversity**	11
Reference	Schirmer 2004	**Use Pattern**	S

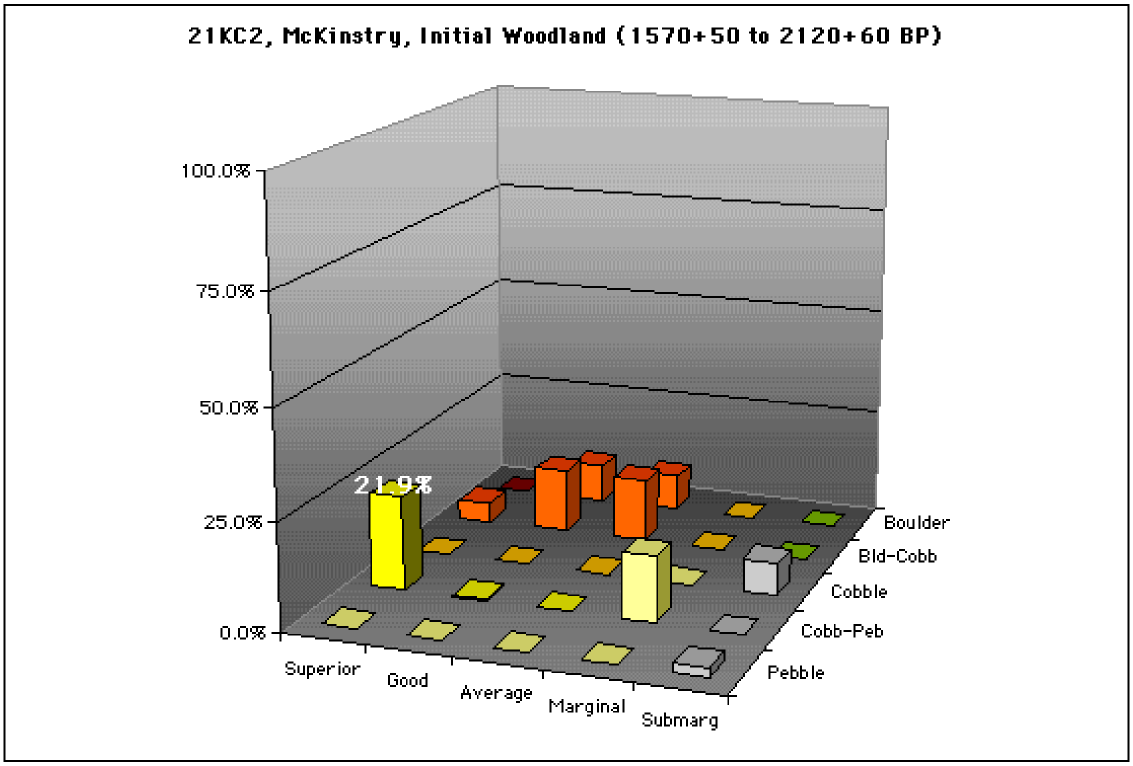
Appendix 2. 21HB55, Beauty Lake Southwest.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 0.1 KLS 99.0		
Boulder-Cobble			SRC 0.2 PdC 0.1		
Cobble					
Cobble-Pebble	HBLC 0.2			Quartz 0.1	
Pebble					nID 0.3

Region / Sub	West Superior / Quartz	**Sample Size**	1,737
Component	Late Paleoindian	**Diversity**	8
Reference	Caine and Goltz 2002	**Use Pattern**	B

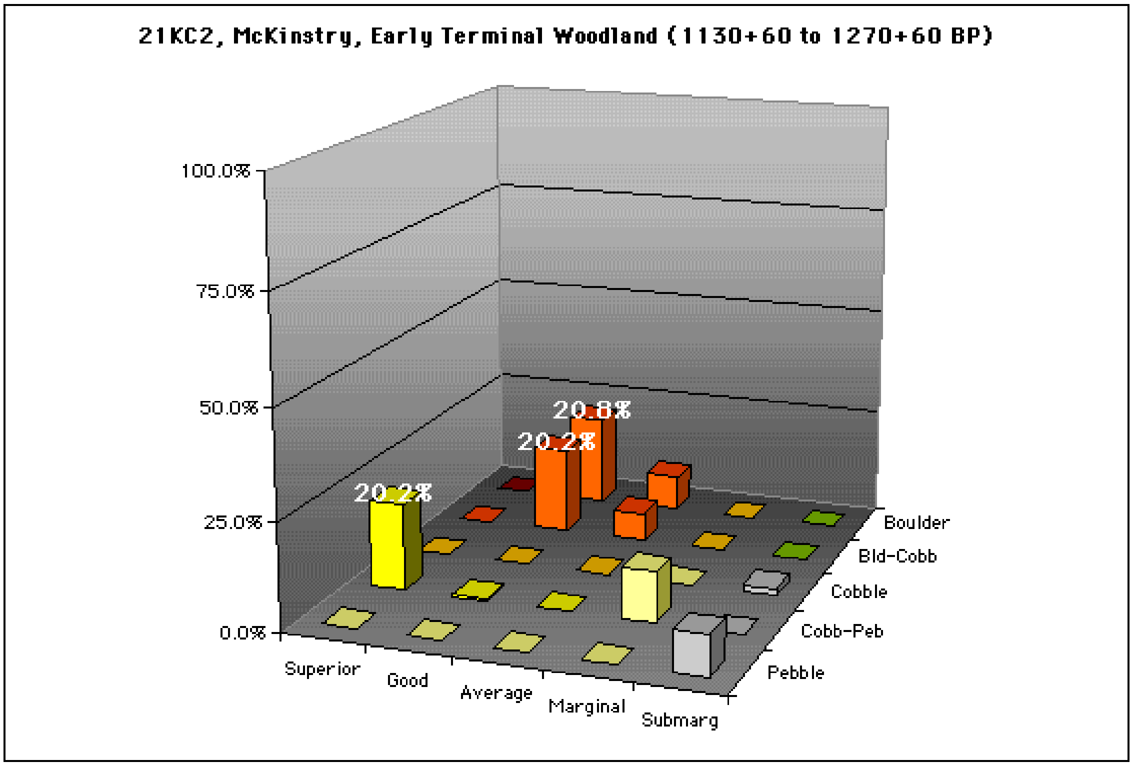
Appendix 2. 21KC2, McKinstry (Initial Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 9.0	KLS 3.9 LoWR 4.7		
Boulder-Cobble	KRF 4.7	GFS 15.0	SRC 15.0		
Cobble					Basaltic 5.2 Granitic 1.7 Oth chop 0.9
Cobble-Pebble	HBLC 21.9	RRC 0.4		Quartz 15.5	
Pebble					nID 2.2

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	233
Component	Initial Woodland (Middle Woodland)	**Diversity**	15
Reference	Thomas and Mather 2006	**Use Pattern**	C?

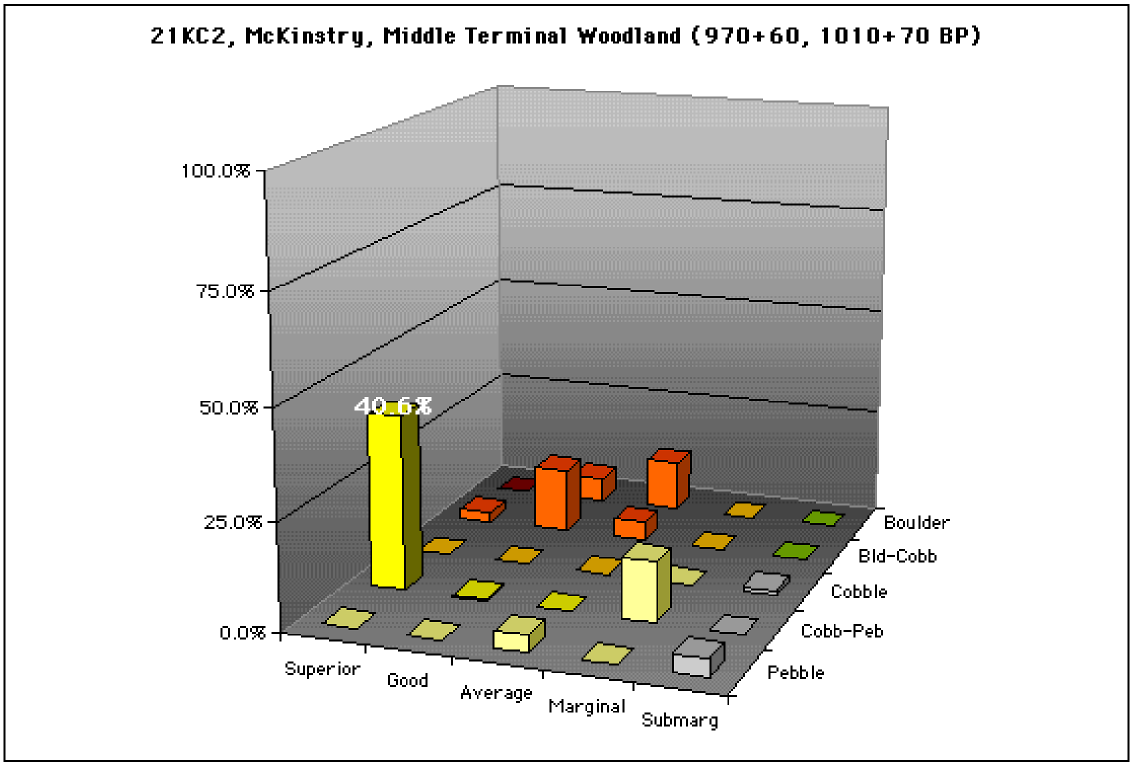
Appendix 2. 21KC2, McKinstry (Early Terminal Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 20.8	KLS 8.4		
Boulder-Cobble		GFS 20.2	SRC 6.7		
Cobble					Basaltic 1.7
Cobble-Pebble	HBLC 20.2	RRC 0.6		Quartz 11.8	
Pebble					nID 9.6

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	178
Component	Early Terminal Woodland (Late Woodland)	**Diversity**	10
Reference	Thomas and Mather 2006	**Use Pattern**	C?

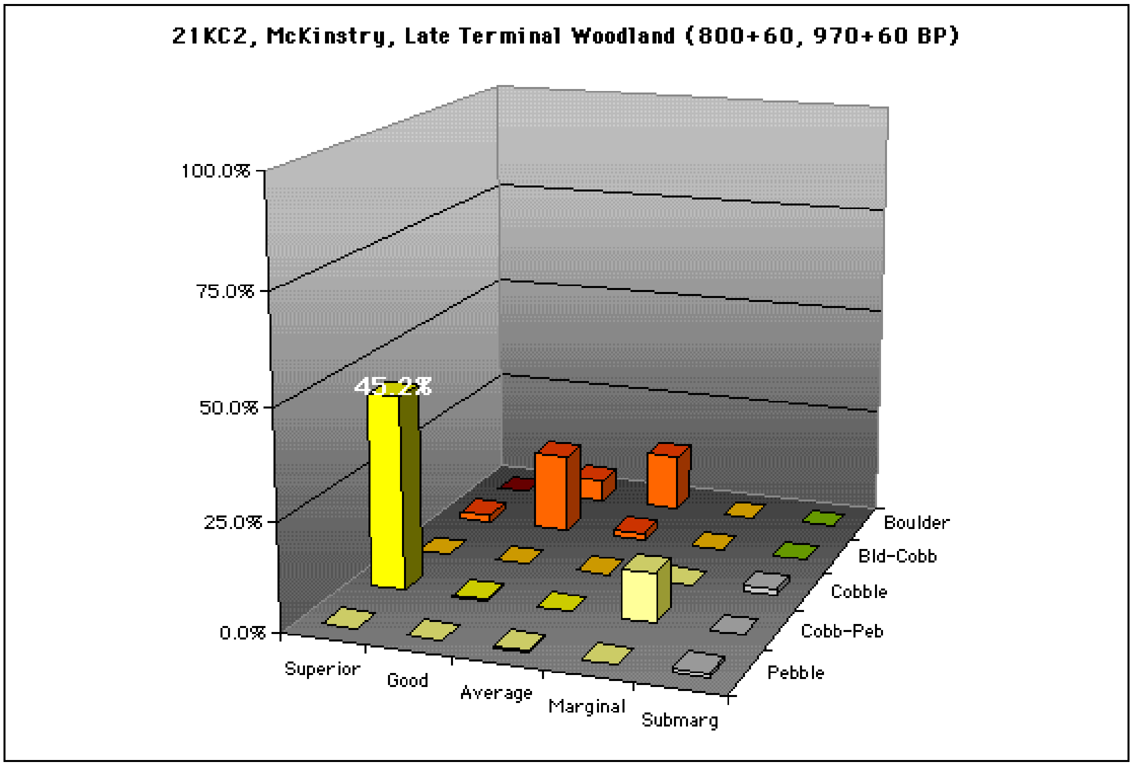
Appendix 2. 21KC2, McKinstry (Middle Terminal Woodland).



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder		Jasper Tac 5.6	KLS 3.3 LoWR 8.6		
Boulder-Cobble	KRF 2.5	GFS 15.3	SRC 4.4		
Cobble					Basaltic 0.9 Granitic 0.3
Cobble-Pebble	HBLC 40.6	RRC 0.4		Quartz 14.1	
Pebble					nID 4.2

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	799
Component	Middle Terminal Woodland (Late Woodland)	**Diversity**	14
Reference	Thomas and Mather 2006	**Use Pattern**	P

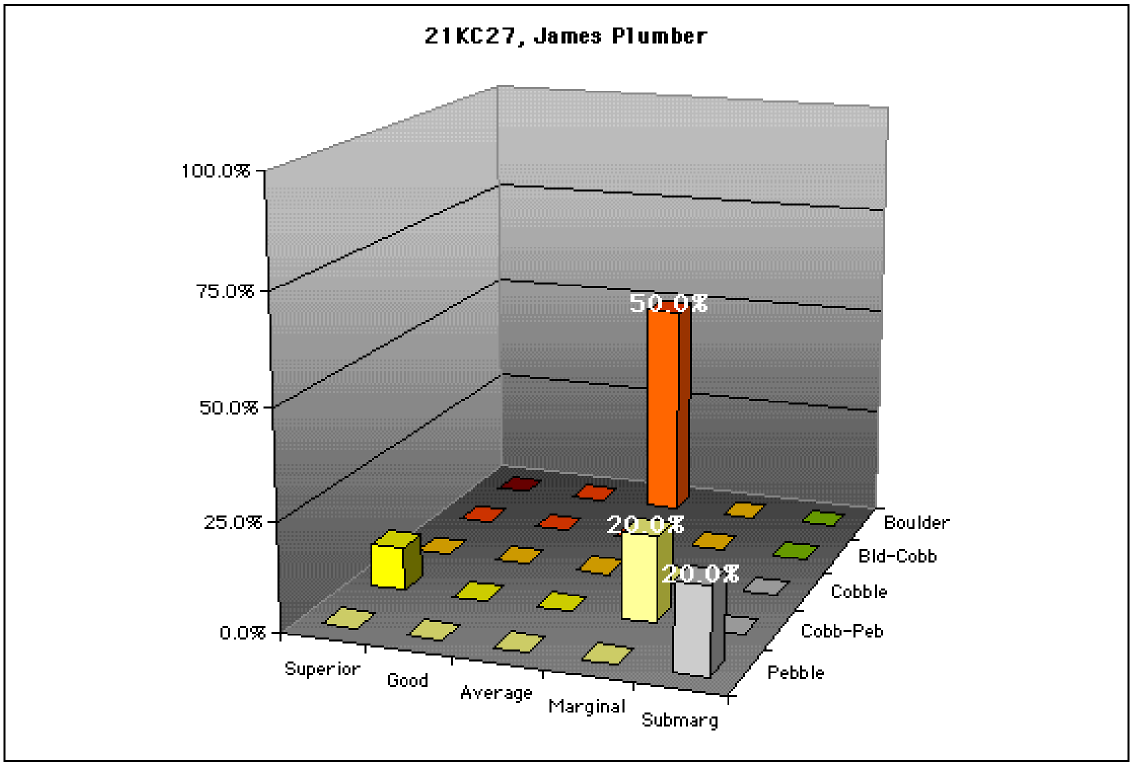
Appendix 2. 21KC2, McKinstry (Late Terminal Woodland).



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder		Jasper Tac 5.0	KLS 3.0 LoWR 10.4		
Boulder-Cobble	KRF 1.6	GFS 18.7 Kakabeka 0.1	SRC 1.7		
Cobble					Basaltic 1.3 Granitic 0.1
Cobble-Pebble	HBLC 45.2	RRC 0.4		Quartz 11.6	
Pebble					nID 0.9

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	1,705
Component	Late Terminal Woodland (Late Woodland)	**Diversity**	15
Reference	Thomas and Mather 2006	**Use Pattern**	P

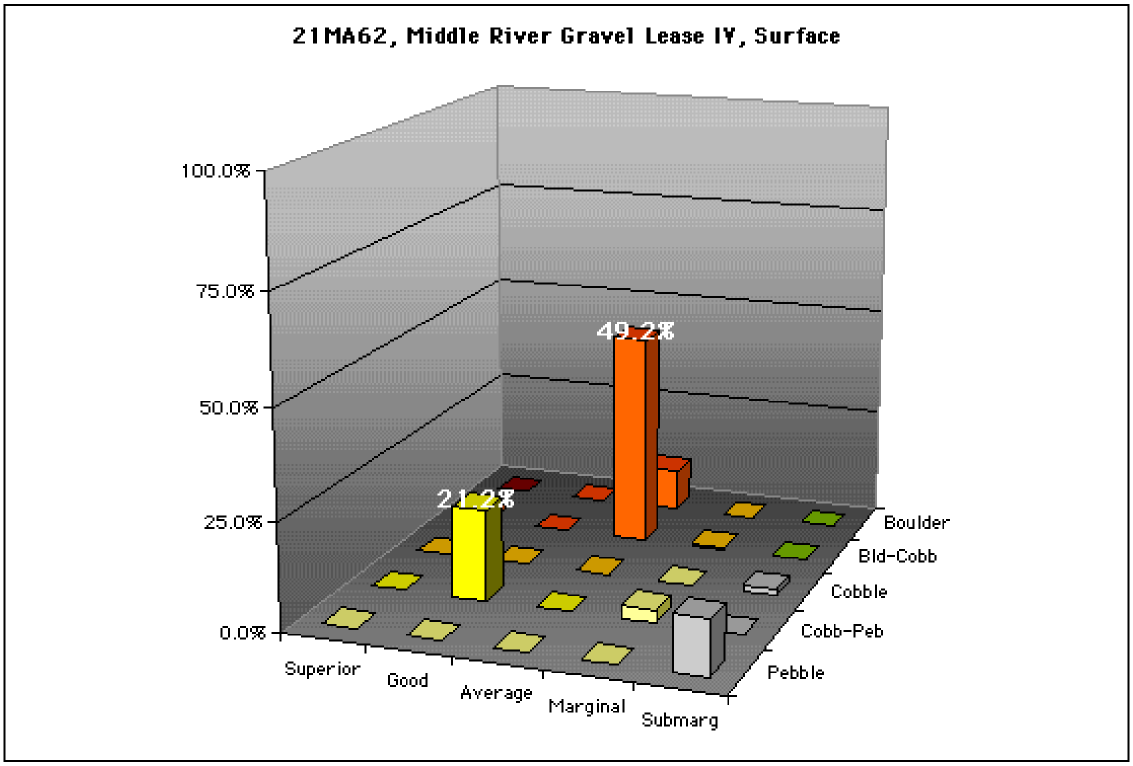
Appendix 2. 21KC27, James Plummer.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder			KLS 40.0 LoWR 10.0		
Boulder-Cobble					
Cobble					
Cobble-Pebble	HBLC 10.0			Quartz 20.0	
Pebble					nID 20.0

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead, Quartz	**Sample Size**	10
Component	Late Paleoindian	**Diversity**	5
Reference	MHS 1986-256, 1988-197, 1988-45	**Use Pattern**	B

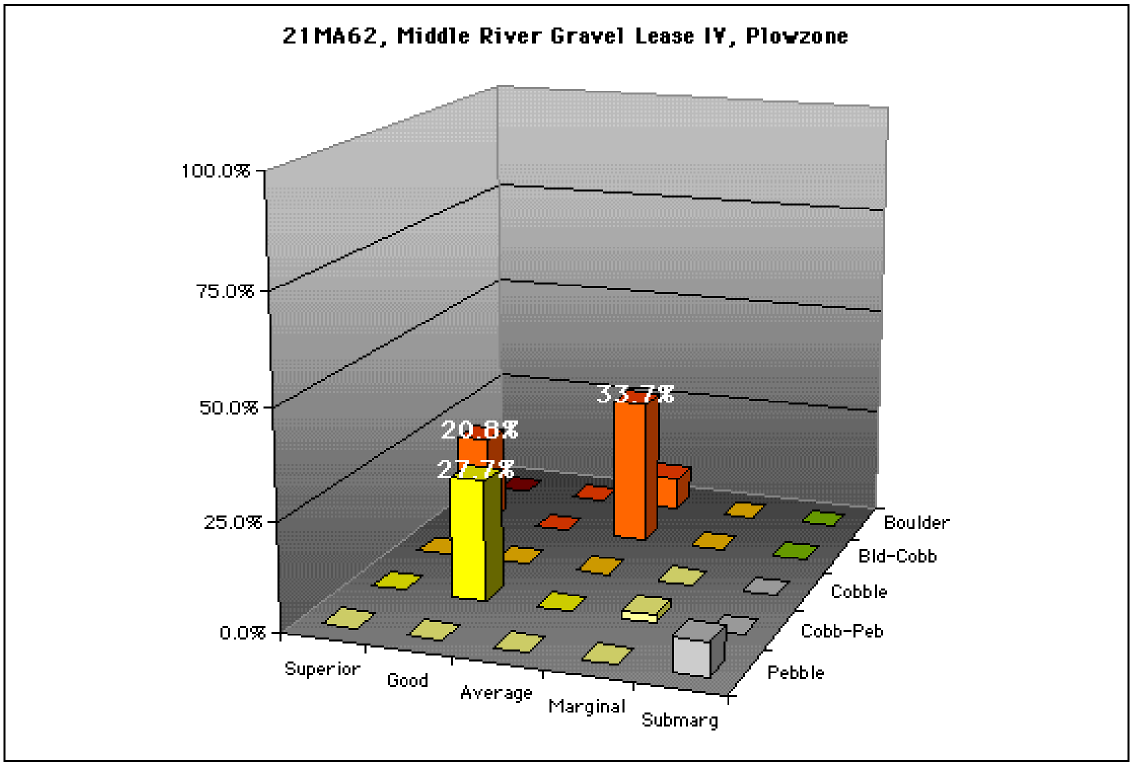
Appendix 2. 21MA62, Middle River Gravel Least IV, Surface.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 1.5 LoWR 6.8 LoWS 1.5		
Boulder-Cobble	KRF 1.5		SRC 47.0 PdC 2.3	TRS 0.8	
Cobble					Basaltic 1.5
Cobble-Pebble		RRC 21.2		Quartz 3.0	
Pebble					nID 12.9

Region / Sub	South Agassiz / Tamarack	**Sample Size**	132
Component	*Surface*	**Diversity**	15
Reference	Peterson 1998	**Use Pattern**	P?

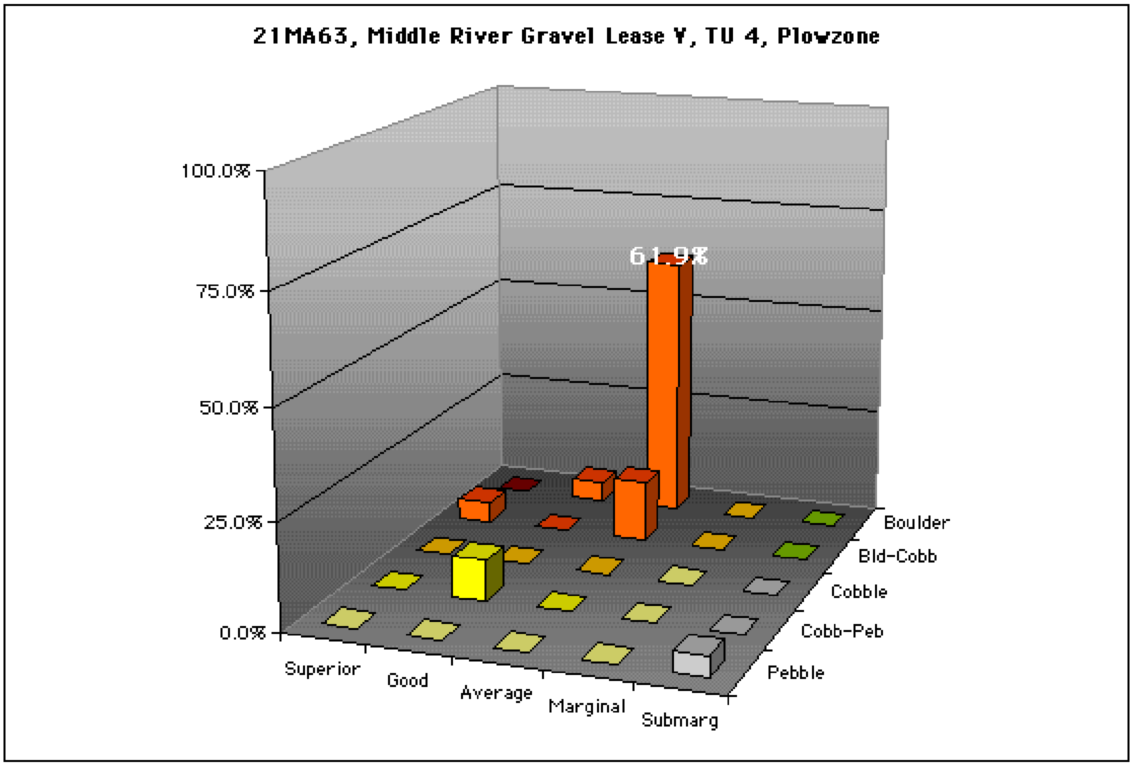
Appendix 2. 21MA62, Middle River Gravel Lease IV, Plowzone.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 7.9		
Boulder-Cobble	KRF 20.8		SRC 33.7		
Cobble					
Cobble-Pebble		RRC 27.7		Quartz 2.0	
Pebble					nID 7.9

Region / Sub	South Agassiz / Tamarack	**Sample Size**	101
Component	*Plowzone*	**Diversity**	7
Reference	Peterson 1998	**Use Pattern**	P?

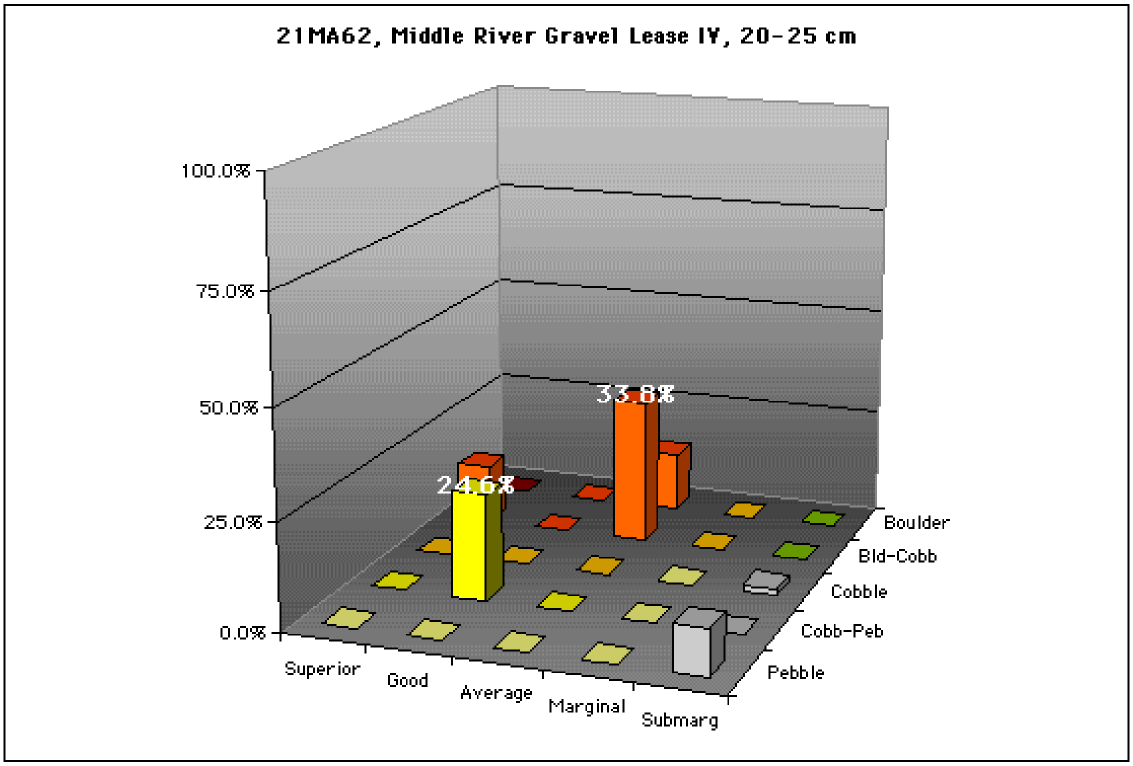
Appendix 2. 21MA63, Middle River Gravel Lease V, Plowzone.



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 4.8	LoWR 61.9		
Boulder-Cobble	KRF 4.8		SRC 14.3		
Cobble					
Cobble-Pebble		RRC 9.5			
Pebble					nID 4.8

Region / Sub	South Agassiz / Tamarack	**Sample Size**	21
Component	*Plowzone*	**Diversity**	6
Reference	Peterson 1998	**Use Pattern**	?

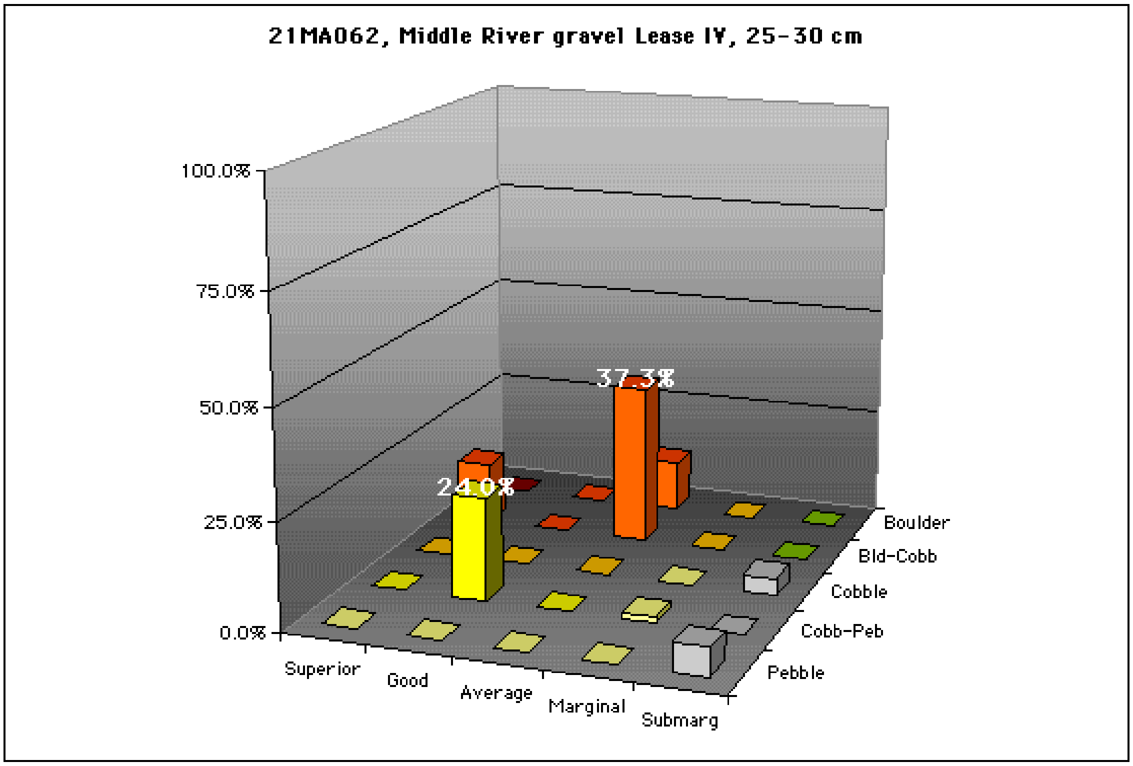
Appendix 2. 21MA62, Middle River Gravel Least IV, 20-25 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 13.8		
Boulder-Cobble	KRF 13.8		SRC 33.8		
Cobble					Basaltic 1.5
Cobble-Pebble		RRC 24.6			
Pebble					nID 10.8

Region / Sub	South Agassiz / Tamarack	**Sample Size**	65
Component	*20-25 cm*	**Diversity**	8
Reference	Peterson 1998	**Use Pattern**	P?

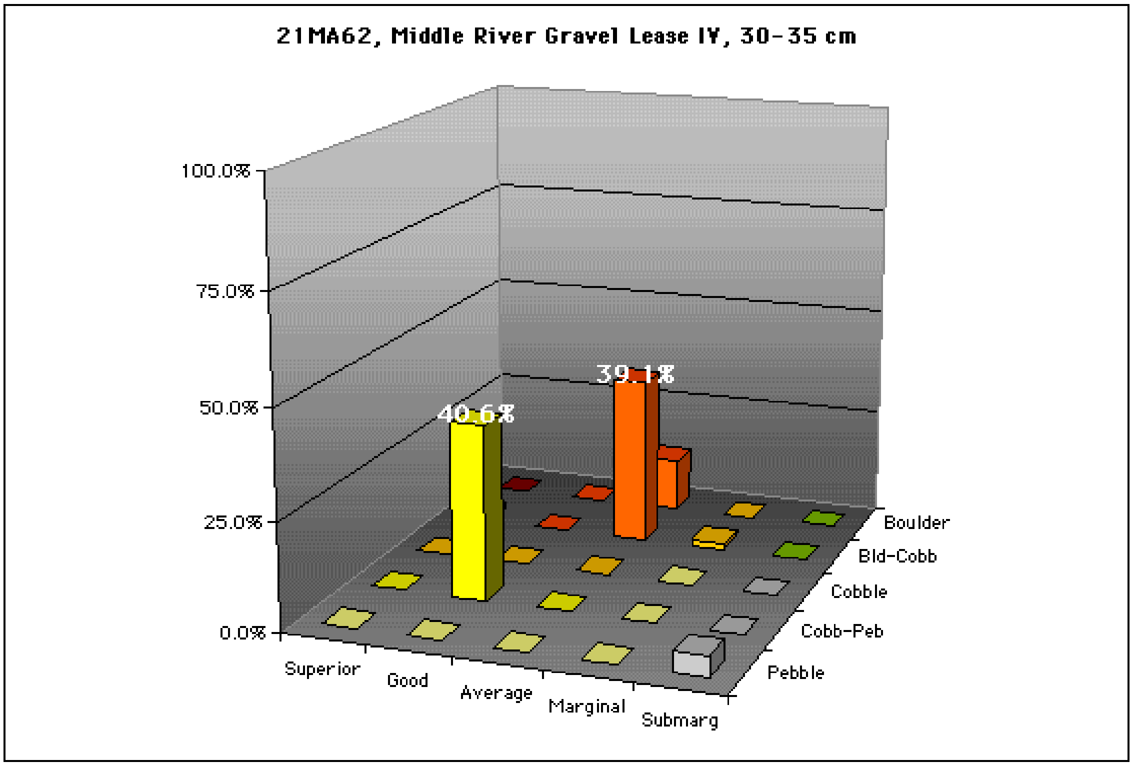
Appendix 2. 21MA62, Middle River Gravel Least IV, 25-30 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 12.0		
Boulder-Cobble	KRF 14.7		SRC 37.3		
Cobble					Basaltic 4.0
Cobble-Pebble		RRC 24.0		Quartz 1.3	
Pebble					nID 6.7

Region / Sub	South Agassiz / Tamarack	**Sample Size**	75
Component	*25-30 cm*	**Diversity**	8
Reference	Peterson 1998	**Use Pattern**	C?

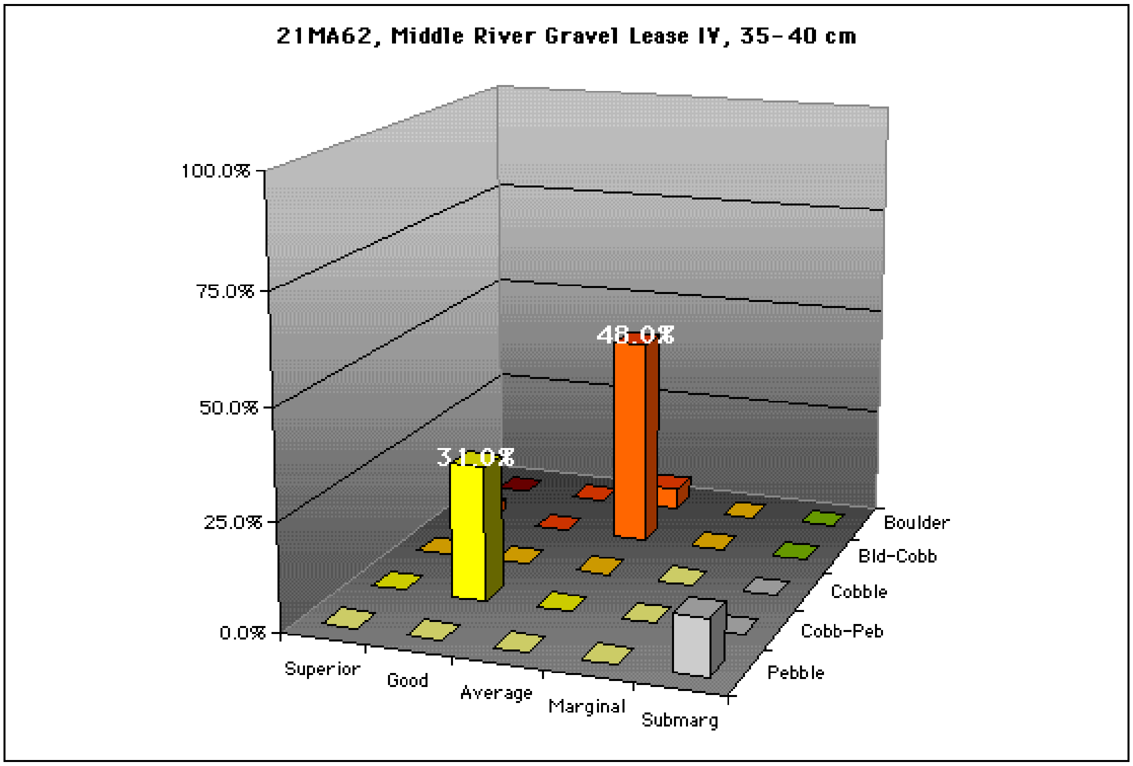
Appendix 2. 21MA62, Middle River Gravel Lease IV, 30-35 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 10.9 LoWS 1.6		
Boulder-Cobble	KRF 1.6		SRC 39.1	TRS 1.6	
Cobble					
Cobble-Pebble		RRC 40.6			
Pebble					nID 4.7

Region / Sub	South Agassiz / Tamarack	**Sample Size**	64
Component	*30-35 cm*	**Diversity**	7
Reference	Peterson 1998	**Use Pattern**	C?

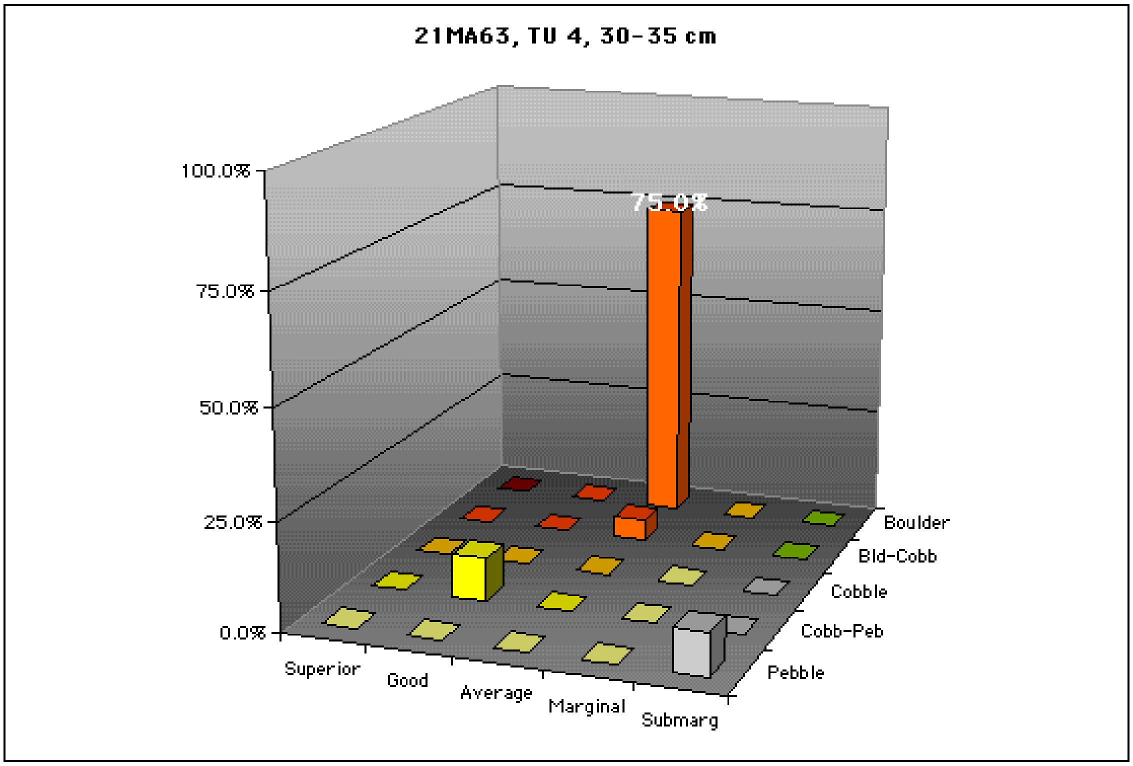
Appendix 2. 21MA62, Middle River Gravel Least IV, 35-40 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 5.0		
Boulder-Cobble	KRF 3.0		SRC 48.0		
Cobble					
Cobble-Pebble		RRC 31.0			
Pebble					nID 13.0

Region / Sub	South Agassiz / Tamarack	**Sample Size**	100
Component	*35-40 cm*	**Diversity**	7
Reference	Peterson 1998	**Use Pattern**	C?

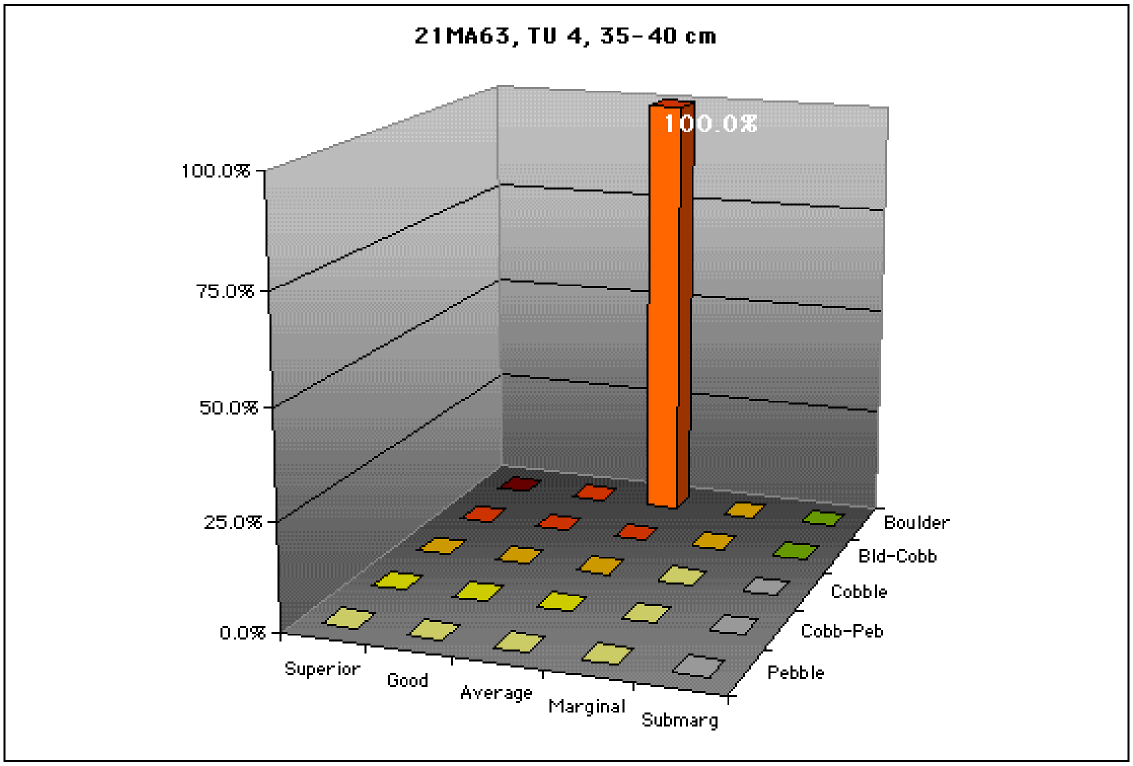
Appendix 2. 21MA63, Middle River Gravel Lease V, 30-35 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 75.0		
Boulder-Cobble			SRC 5.0		
Cobble					
Cobble-Pebble		RRC 10.0			
Pebble					nID 10.0

Region / Sub	South Agassiz / Tamarack	**Sample Size**	20
Component	*30-35 cm*	**Diversity**	4
Reference	Peterson 1998	**Use Pattern**	?

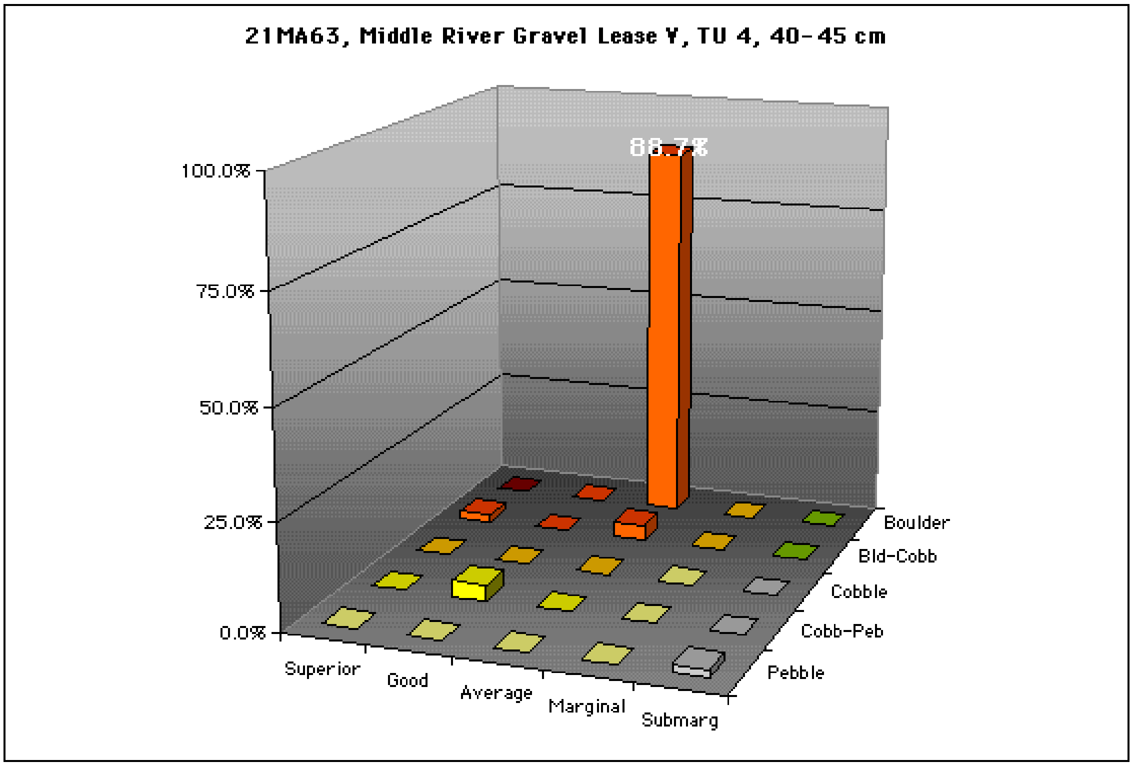
Appendix 2. 21MA63, Middle River Gravel Lease V, 35-40 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 100.0		
Boulder-Cobble					
Cobble					
Cobble-Pebble					
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	11
Component	*35-40 cm*	**Diversity**	1
Reference	Peterson 1998	**Use Pattern**	?

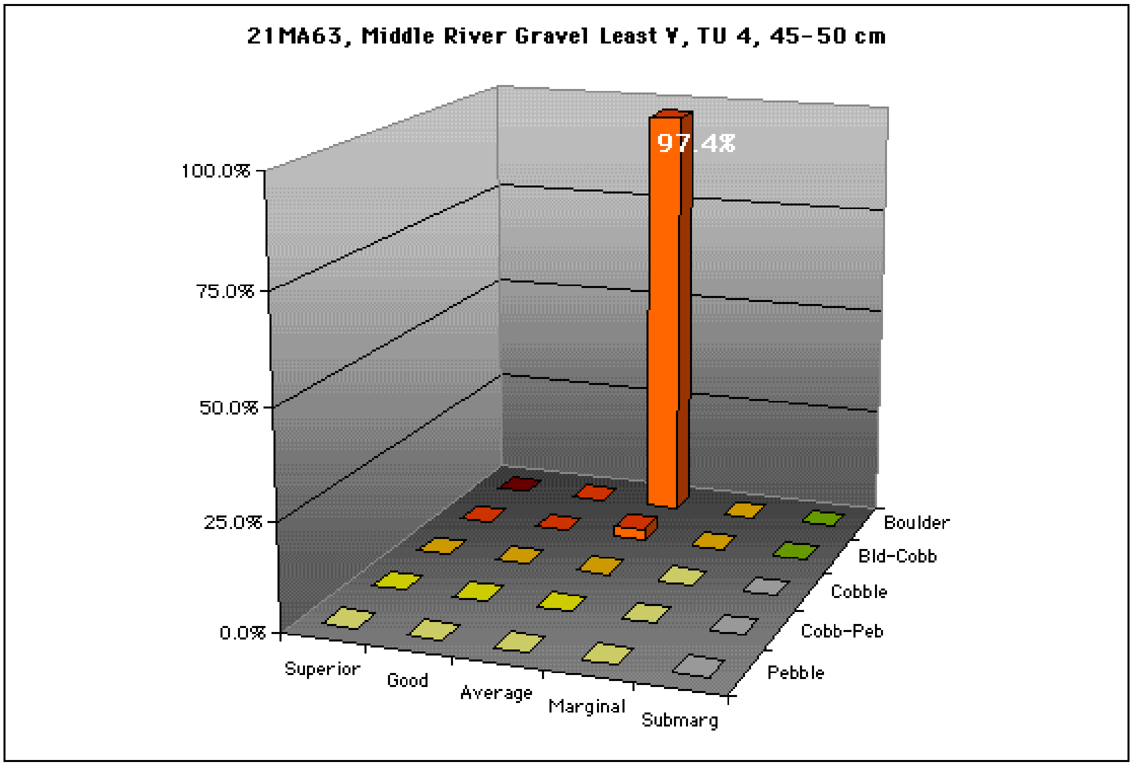
Appendix 2. 21MA63, Middle River Gravel Lease V, 40-45 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 88.7		
Boulder-Cobble	KRF 1.9		SRC 3.8		
Cobble					
Cobble-Pebble		RRC 3.8			
Pebble					nID 1.9

Region / Sub	South Agassiz / Tamarack	**Sample Size**	53
Component	*40-45 cm*	**Diversity**	5
Reference	Peterson 1998	**Use Pattern**	?

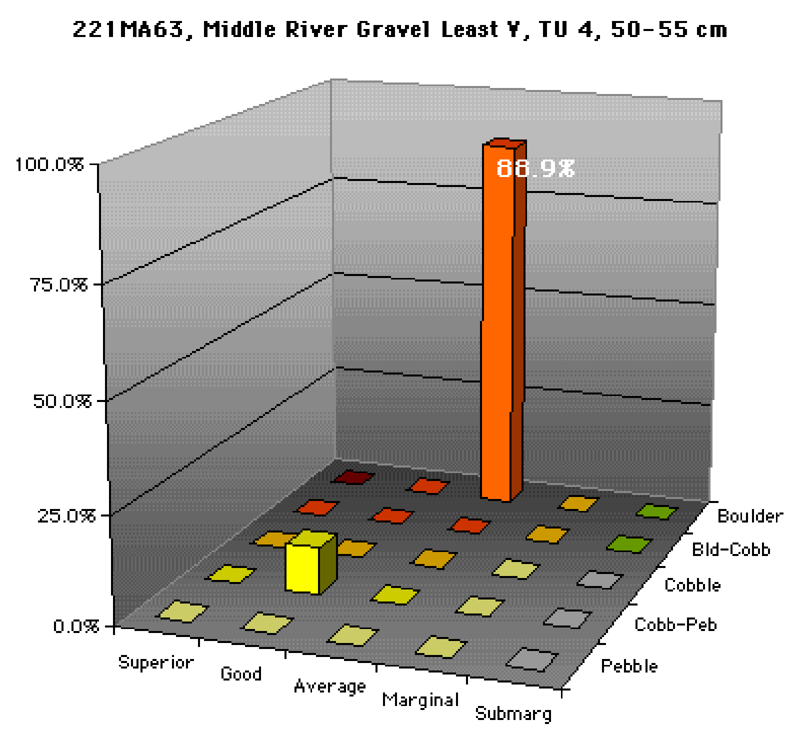
Appendix 2. 21MA63, Middle River Gravel Lease V, 45-50 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 97.4		
Boulder-Cobble			SRC 2.6		
Cobble					
Cobble-Pebble					
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	39
Component	*45-50 cm*	**Diversity**	2
Reference	Peterson 1998	**Use Pattern**	?

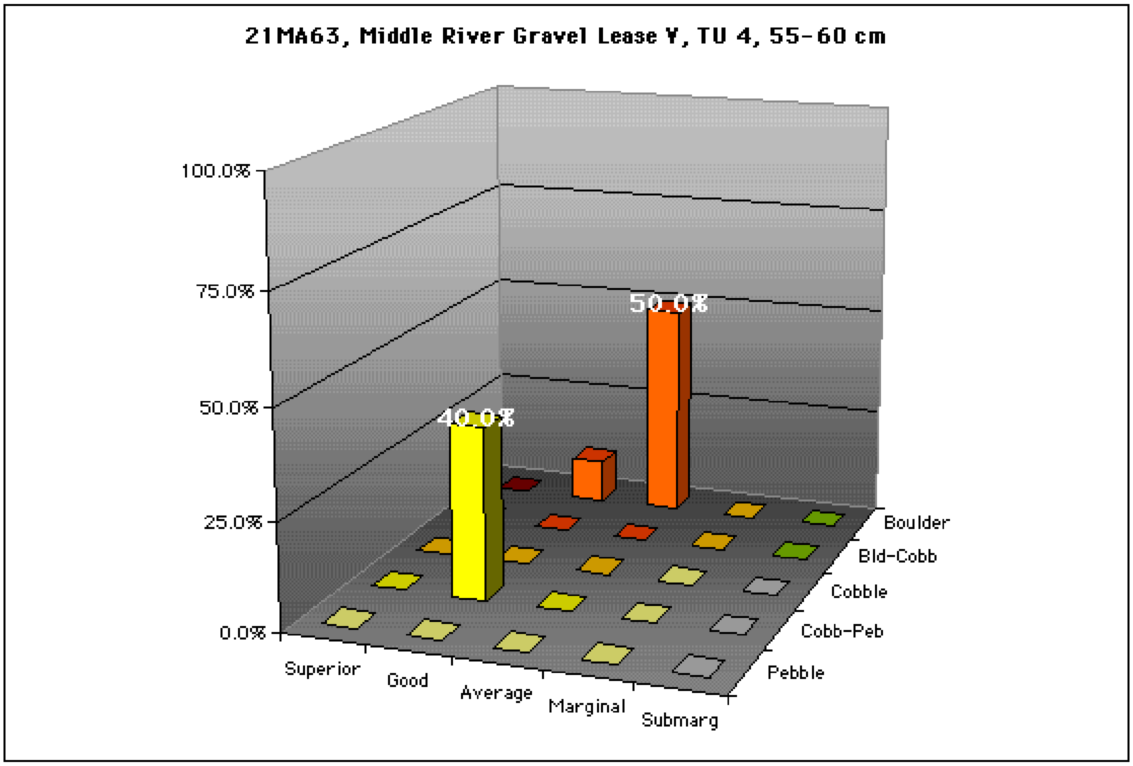
Appendix 2. 21MA63, Middle River Gravel Lease V, 50-55 cm.



	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 88.9		
Boulder-Cobble					
Cobble					
Cobble-Pebble		RRC 11.1			
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	9
Component	*50-55 cm*	**Diversity**	2
Reference	Peterson 1998	**Use Pattern**	?

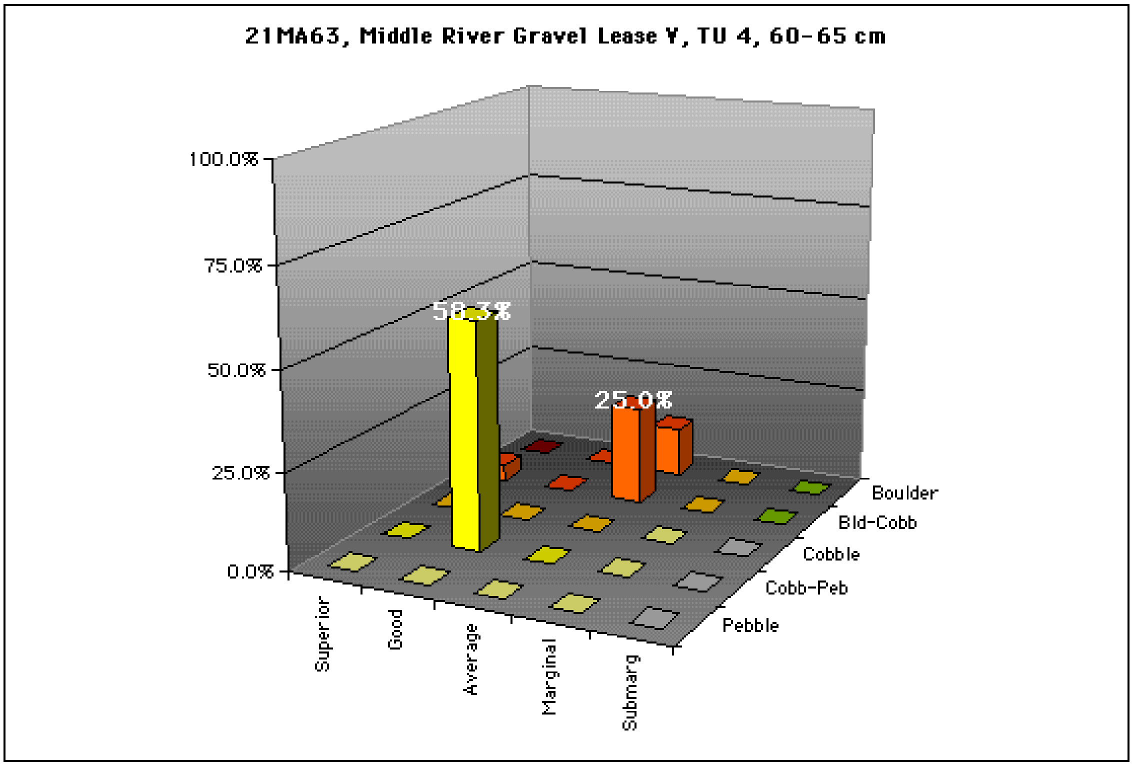
Appendix 2. 21MA63, Middle River Gravel Lease V, 55-60 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 10.0	LoWR 50.0		
Boulder-Cobble					
Cobble					
Cobble-Pebble		RRC 40.0			
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	10
Component	*55-60 cm*	**Diversity**	3
Reference	Peterson 1998	**Use Pattern**	C?

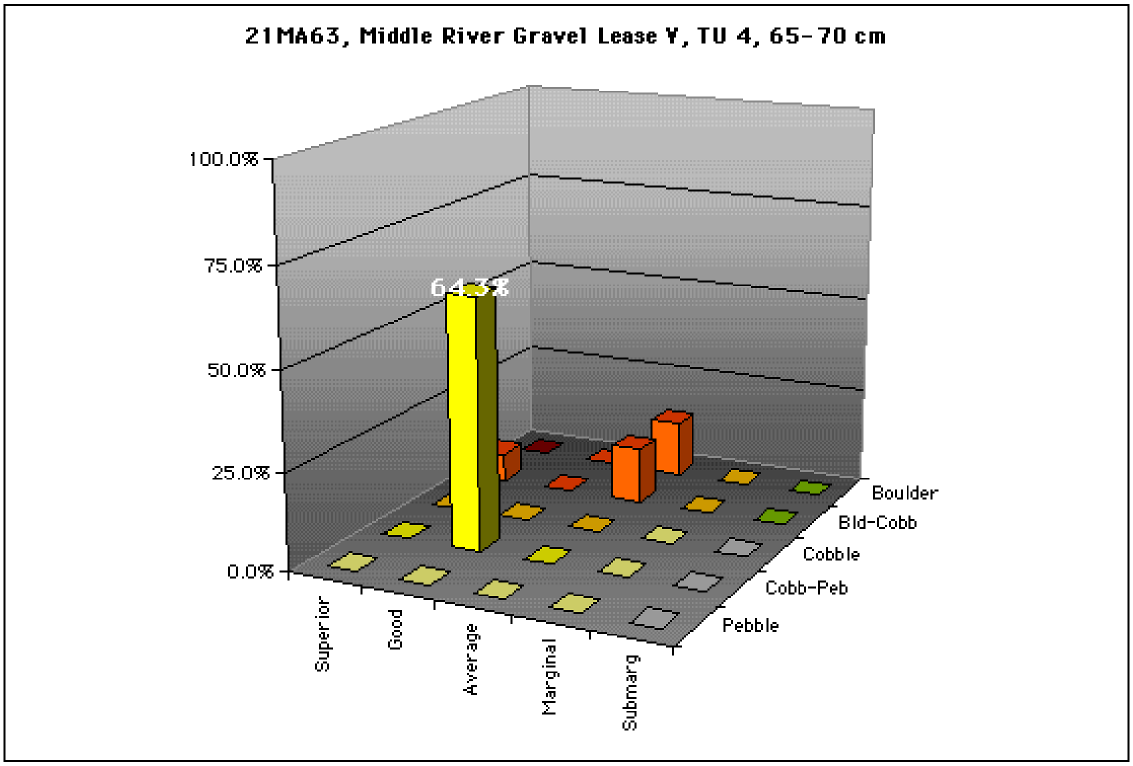
Appendix 2. 21MA63, Middle River Gravel Lease V, 60-65 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 12.5		
Boulder-Cobble	KRF 4.2		SRC 25.0		
Cobble					
Cobble-Pebble		RRC 58.3			
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	24
Component	*60-65 cm*	**Diversity**	4
Reference	Peterson 1998	**Use Pattern**	C?

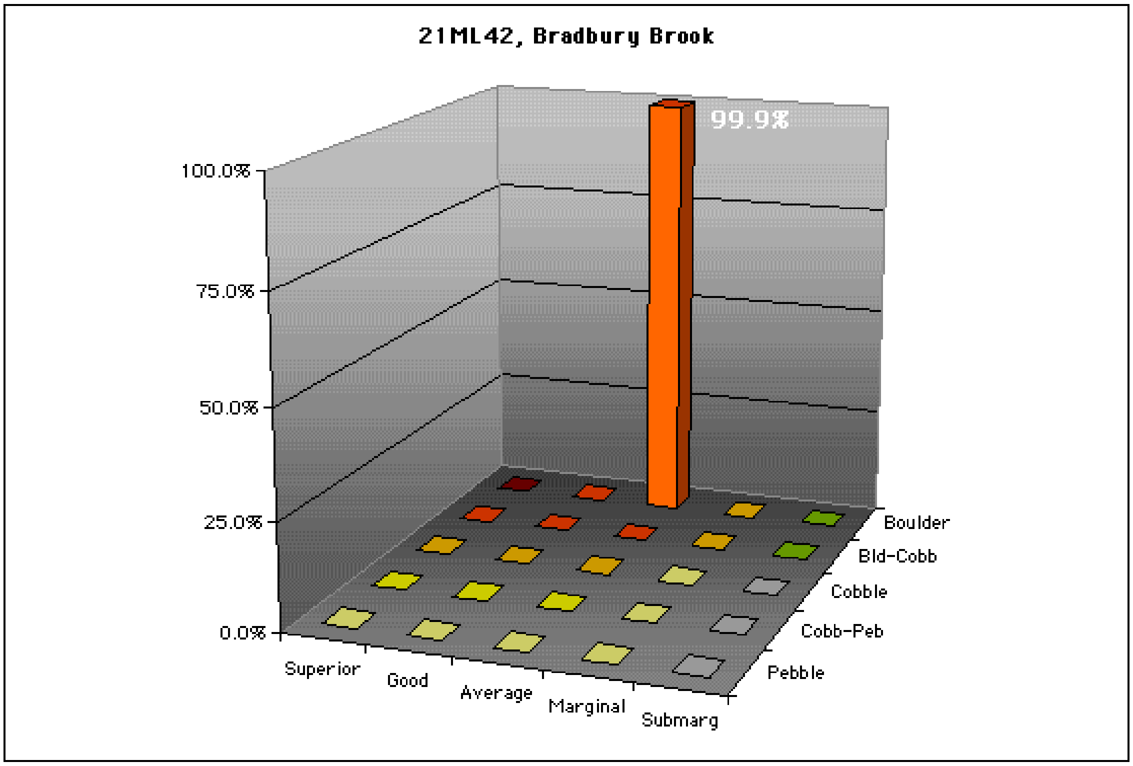
Appendix 2. 21MA63, Middle River Gravel Lease V, 65-70 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 14.3		
Boulder-Cobble	KRF 7.1		SRC 14.3		
Cobble					
Cobble-Pebble		RRC 64.3			
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	14
Component	*65-70 cm*	**Diversity**	4
Reference	Peterson 1998	**Use Pattern**	C?

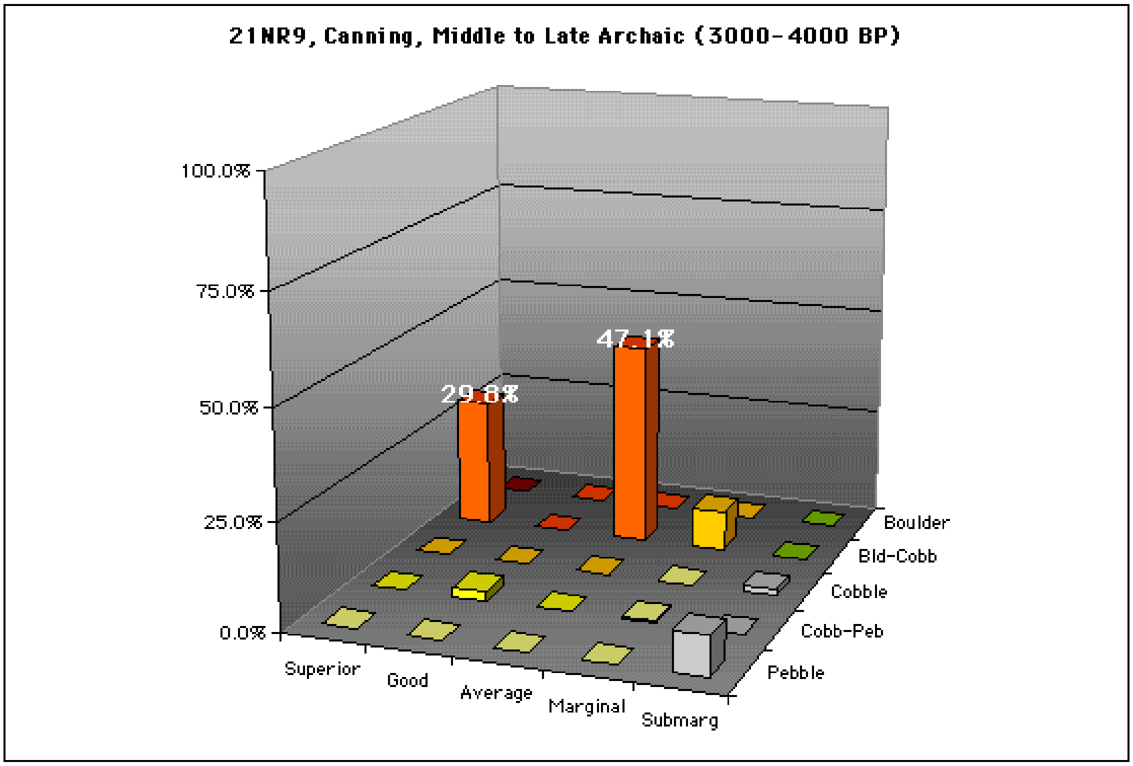
Appendix 2. 21ML42, Bradbury Brook.



	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 99.9		
Boulder-Cobble	Burlington<0.1 KRF < 0.1	GFS < 0.1 Kakabeka < 0.1	SRC < 0.1 PdC < 0.1		
Cobble	GMC < 0.1				
Cobble-Pebble				Quartz < 0.1	
Pebble				LSA < 0.1	nID < 0.1

Region / Sub	West Superior / Quartz	**Sample Size**	126,852
Component	Late Paleoindian	**Diversity**	12
Reference	Malik and Bakken 1999	**Use Pattern**	B

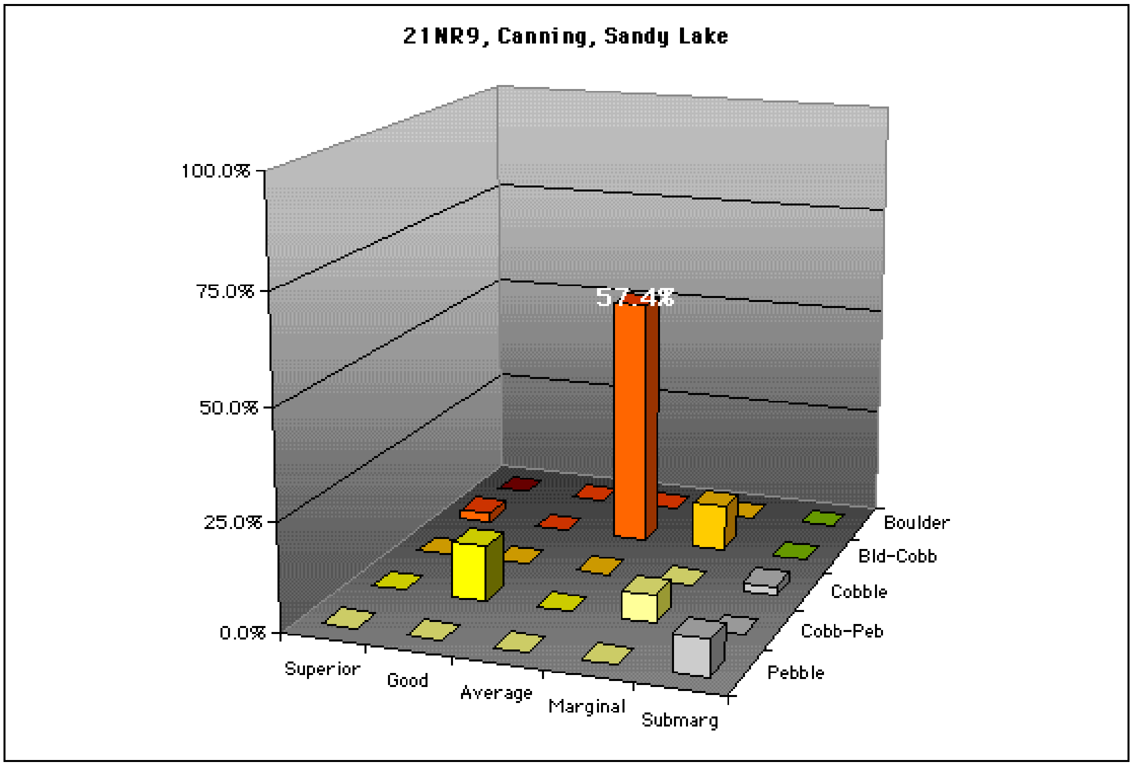
Appendix 2. 21NR9, Canning (Middle to Late Archaic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 0.3		
Boulder-Cobble	KRF 29.8		SRC 47.1	TRS 9.4	
Cobble					Basaltic 1.3
Cobble-Pebble		RRC 2.3		Quartz 0.4	
Pebble					nID 9.4

Region / Sub	South Agassiz / Upper Red	**Sample Size**	1,196
Component	Middle to Late Archaic	**Diversity**	11
Reference	Michlovic 1986	**Use Pattern**	C

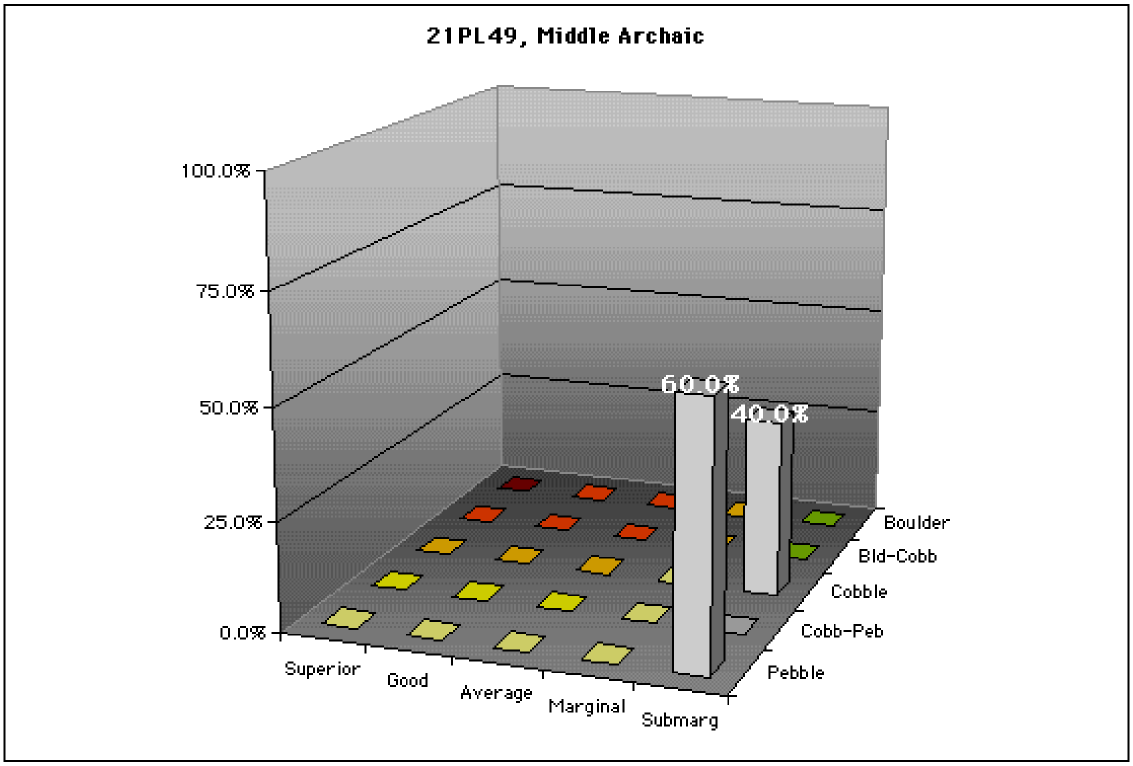
Appendix 2. 21NR9, Canning (Woodland -- Sandy Lake).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 2.1		SRC 57.4	TRS 10.6	
Cobble					Basaltic 2.1
Cobble-Pebble		RRC 12.8		Quartz 6.4	
Pebble					nID 8.5

Region / Sub	South Agassiz / Upper Red	**Sample Size**	47
Component	Late Woodland (Sandy Lake)	**Diversity**	8
Reference	Michlovic 1986	**Use Pattern**	P

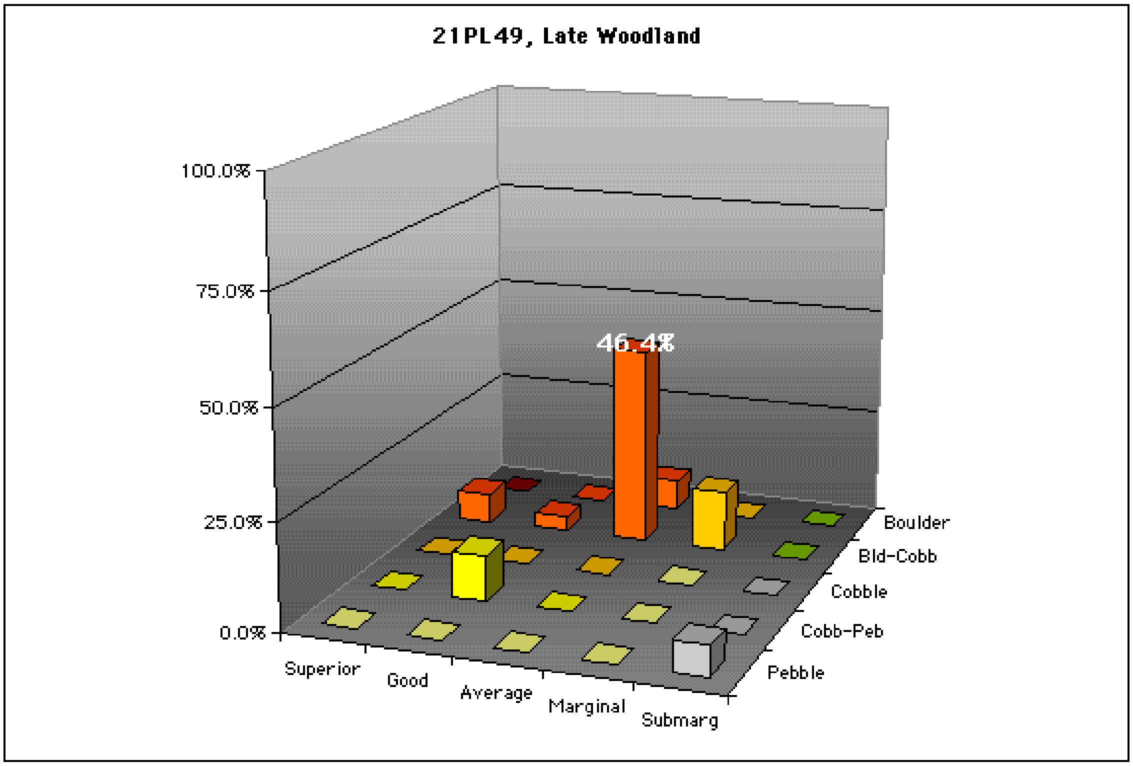
Appendix 2. 21PL49 (Middle Archaic).



	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble					
Cobble					Basaltic 40.0
Cobble-Pebble					
Pebble					nID 60.0

Region / Sub	South Agassiz / Tamarack	**Sample Size**	5
Component	Middle Archaic	**Diversity**	3
Reference	Florin and Wergin 2001; Florin et al. 2001	**Use Pattern**	C

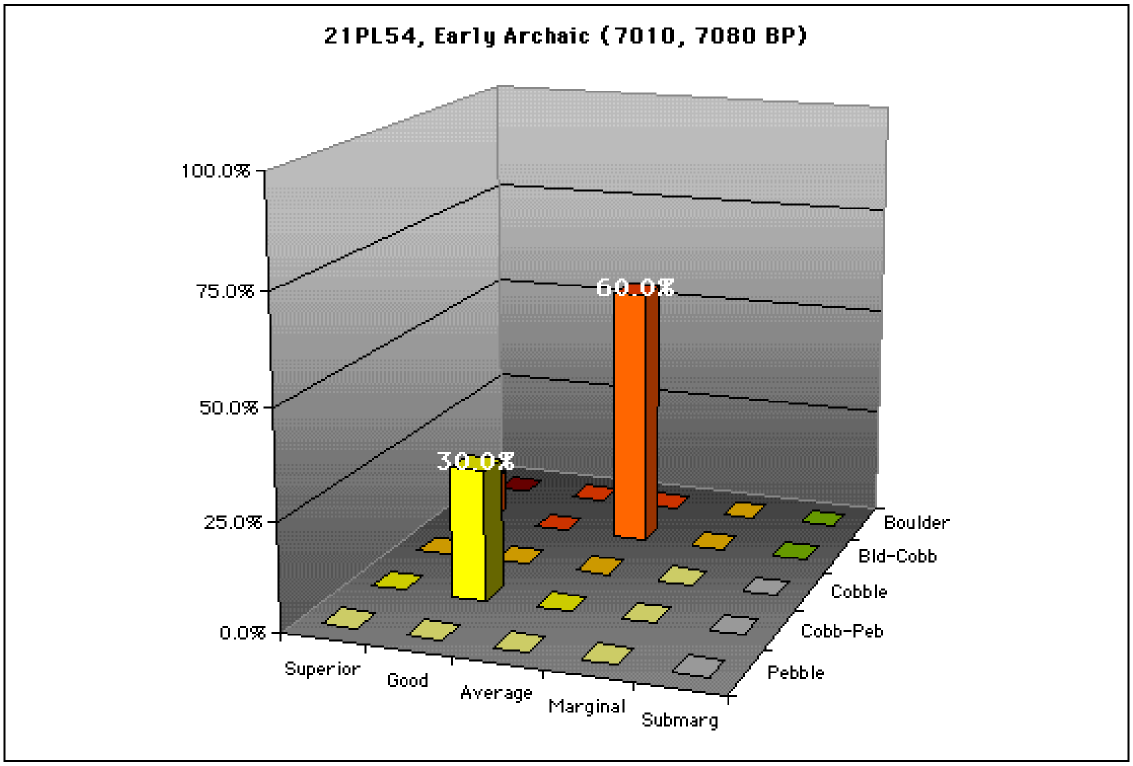
Appendix 2. 21PL49 (Late Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 3.6 LoWR 3.6		
Boulder-Cobble	KRF 7.1	Galena 3.6	SRC 46.4		
Cobble					
Cobble-Pebble		RRC 10.7			
Pebble					nID 7.1

Region / Sub	South Agassiz / Tamarack	**Sample Size**	28
Component	Late Woodland	**Diversity**	8
Reference	Florin and Wergin 2001; Florin et al. 2001	**Use Pattern**	P?

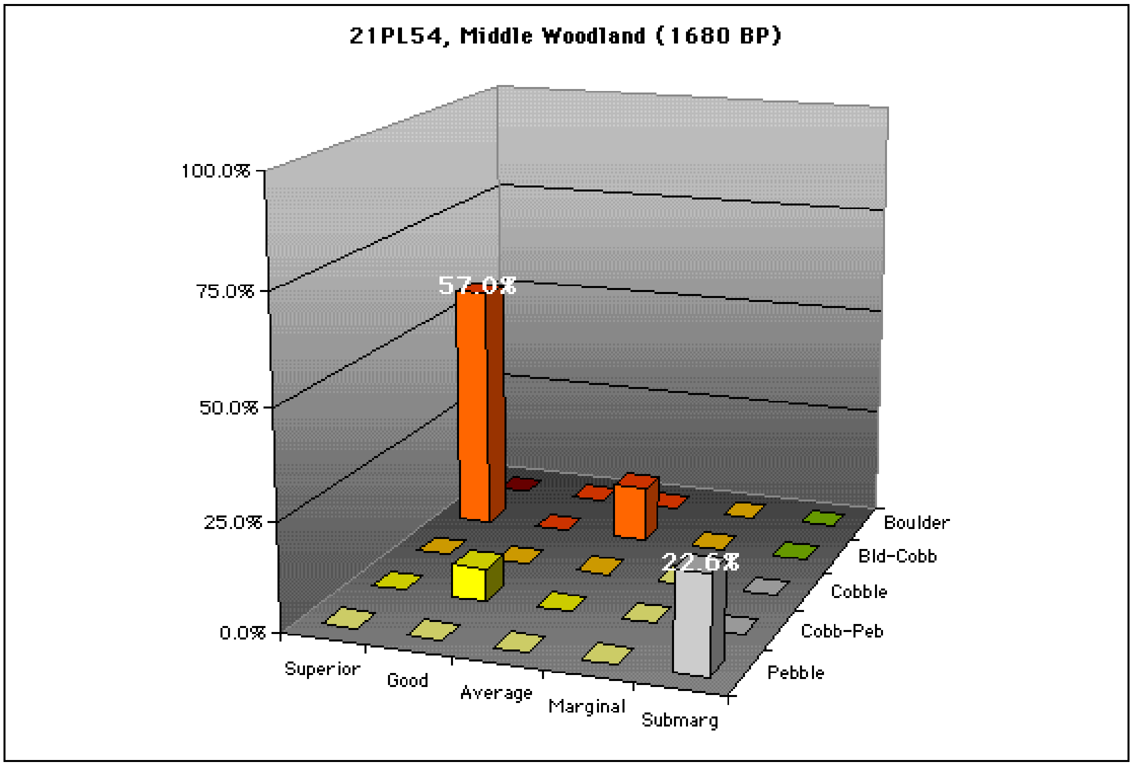
Appendix 2. 21PL54 (Early Archaic).



	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 10.0		SRC 60.0		
Cobble					
Cobble-Pebble		RRC 30.0			
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	10
Component	Early Archaic	**Diversity**	3
Reference	Florin et al. 2001	**Use Pattern**	C

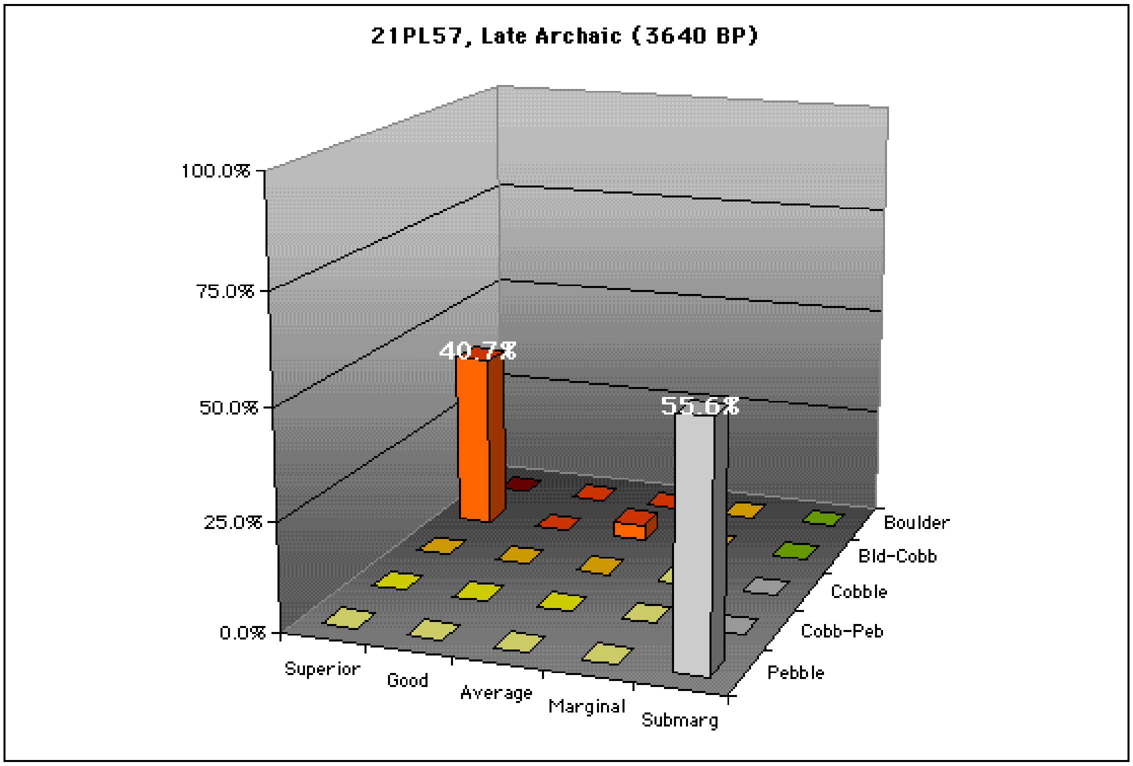
Appendix 2. 21PL54 (Middle Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 57.0		SRC 12.9		
Cobble					
Cobble-Pebble		RRC 7.5			
Pebble					nID 22.6

Region / Sub	South Agassiz / Tamarack	**Sample Size**	93
Component		**Diversity**	5
Reference	Florin et al. 2001	**Use Pattern**	C?

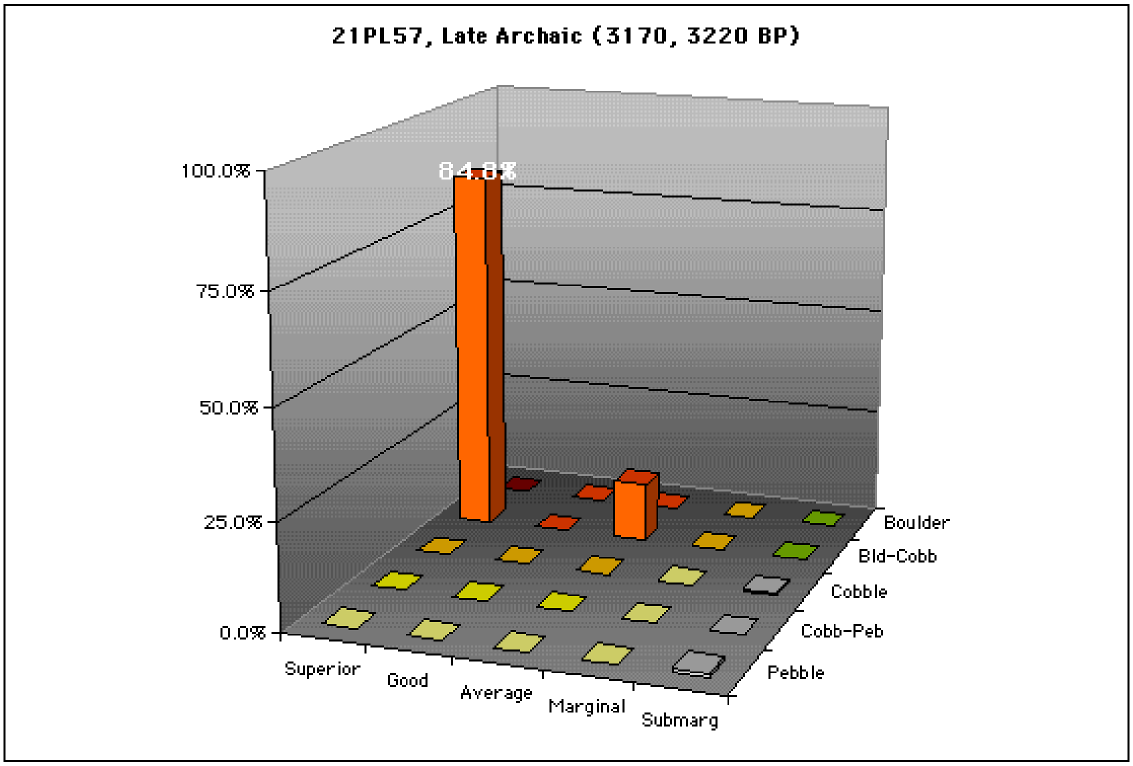
Appendix 2. 21PL57 (Late Archaic, lower).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 40.7		PdC 3.7		
Cobble					
Cobble-Pebble					
Pebble					nID 55.6

Region / Sub	South Agassiz / Tamarack	**Sample Size**	27
Component	Late Archaic	**Diversity**	3
Reference	Florin et al. 2001	**Use Pattern**	C

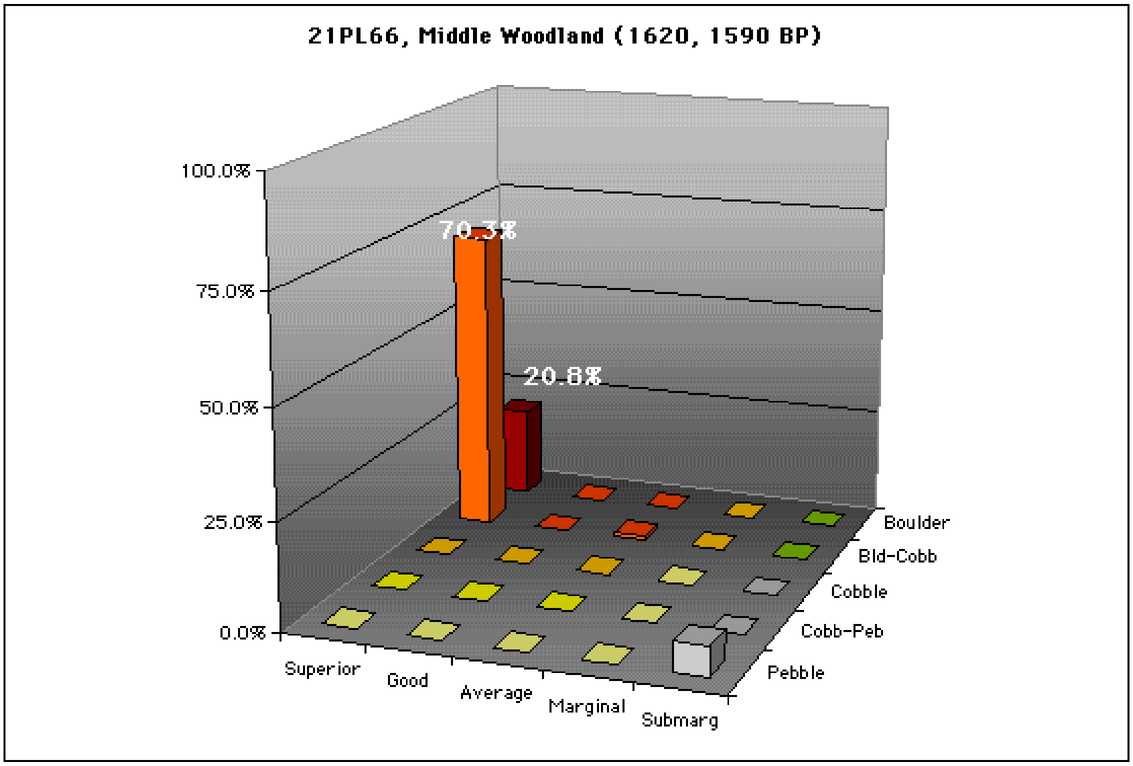
Appendix 2. 21PL57 (Late Archaic, upper).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 84.8		SRC 13.9		
Cobble					Basaltic 0.5
Cobble-Pebble					
Pebble					nID 0.9

Region / Sub	South Agassiz / Tamarack	**Sample Size**	433
Component		**Diversity**	4
Reference	Florin et al. 2001	**Use Pattern**	C

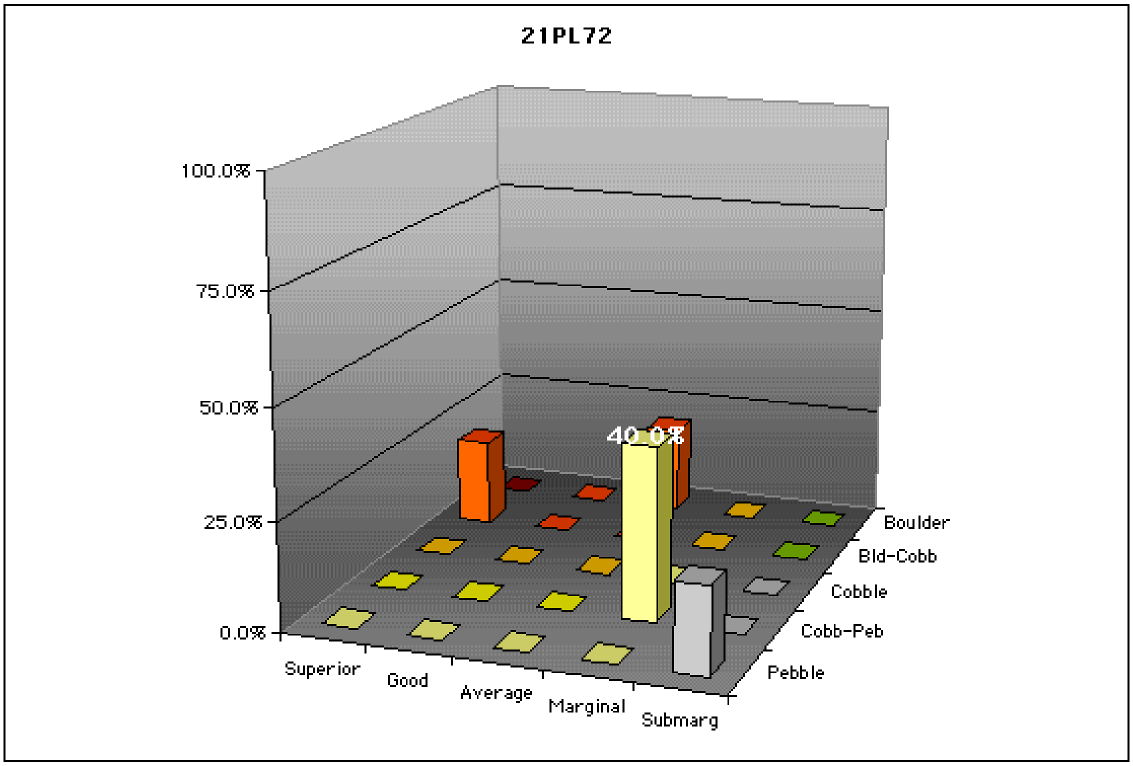
Appendix 2. 21PL66 (Middle Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder	Obsidian 20.8				
Boulder-Cobble	KRF 70.3		SRC 1.0		
Cobble					
Cobble-Pebble					
Pebble					nID 6.9

Region / Sub	South Agassiz / Tamarack	**Sample Size**	101
Component	Middle Woodland	**Diversity**	5
Reference	Florin et al. 2001	**Use Pattern**	C?

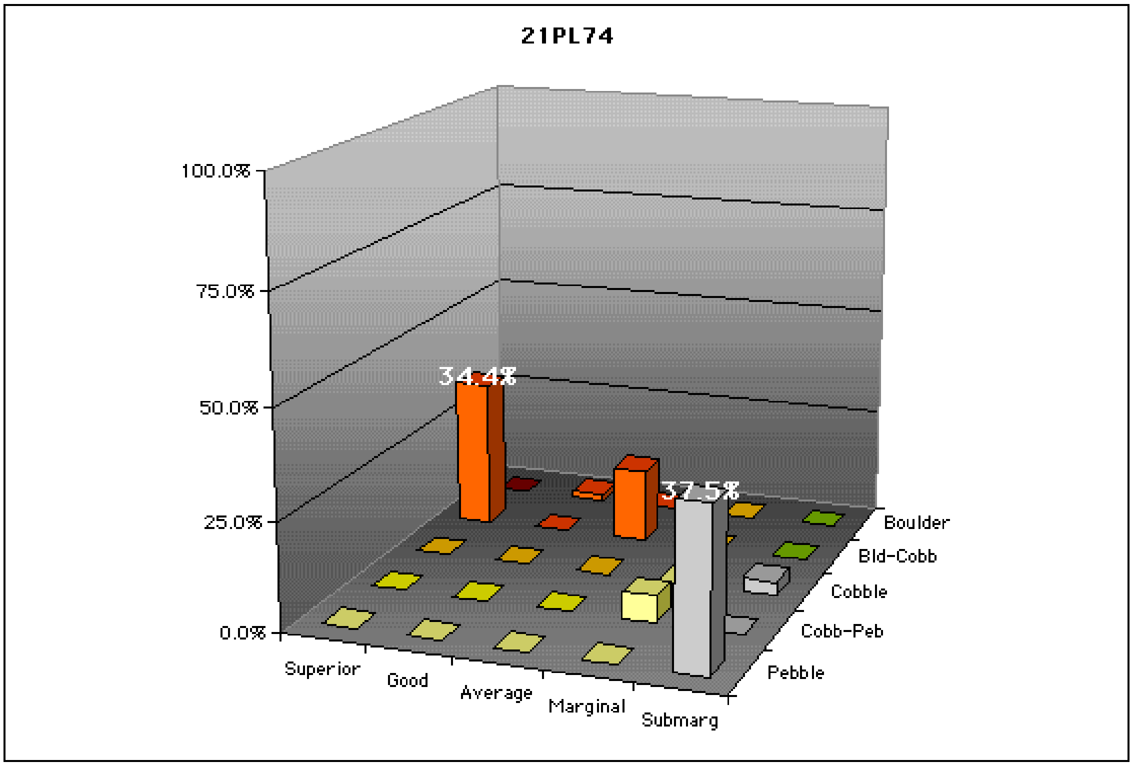
Appendix 2. 21PL72 (Middle Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 20.0		
Boulder-Cobble	KRF 20.0				
Cobble					
Cobble-Pebble				Quartz 40.0	
Pebble					nID 20.0

Region / Sub	South Agassiz / Tamarack	**Sample Size**	5
Component	Middle Woodland	**Diversity**	4
Reference	Harvey et al. 2005	**Use Pattern**	C?

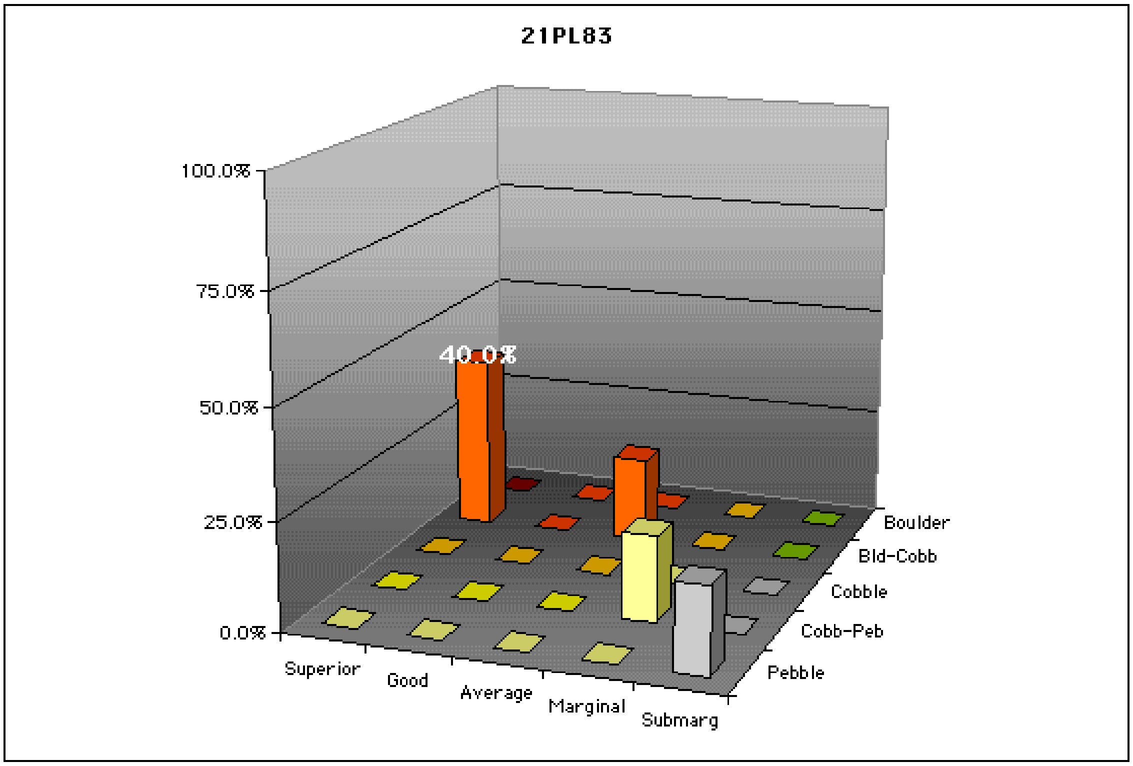
Appendix 2. 21PL74 (Middle Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 1.6			
Boulder-Cobble	KRF 34.4		SRC 17.2		
Cobble					Basaltic 3.1
Cobble-Pebble				Quartz 6.3	
Pebble					nID 37.5

Region / Sub	South Agassiz / Tamarack	**Sample Size**	64
Component	Middle Woodland	**Diversity**	8
Reference	Harvey et al. 2005	**Use Pattern**	C?

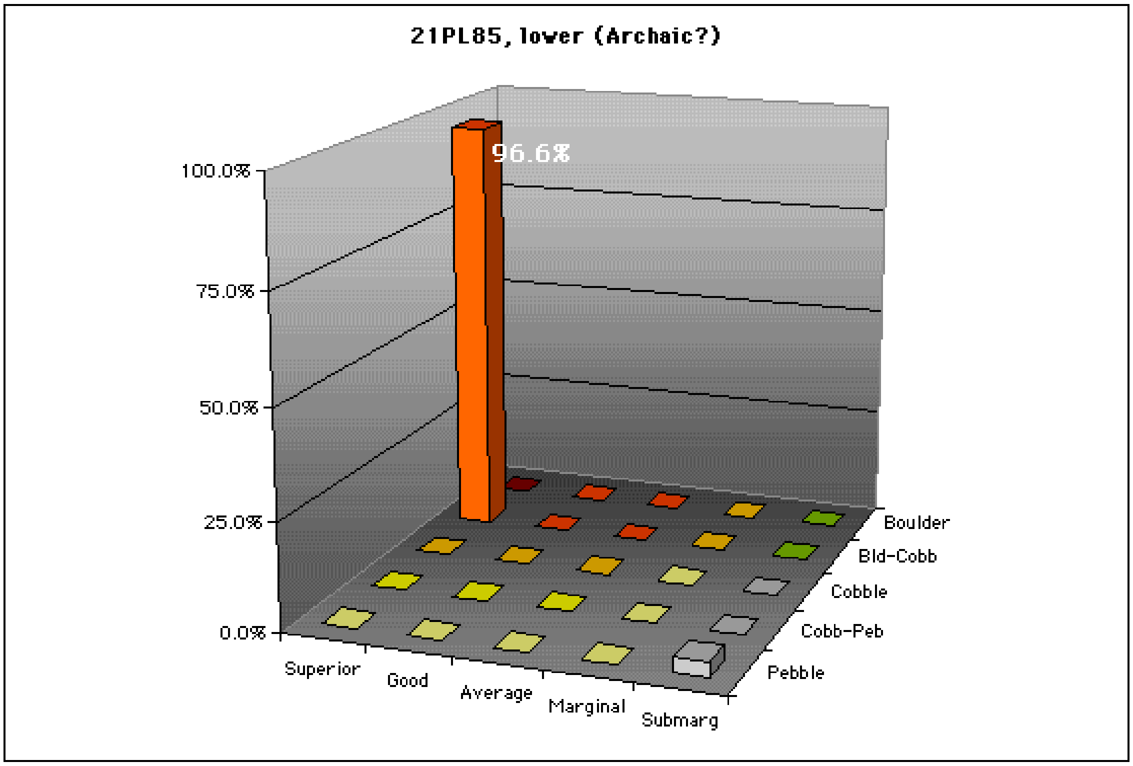
Appendix 2. 21PL83 (Late Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 40.0		SRC 20.0		
Cobble					
Cobble-Pebble				Quartz 20.0	
Pebble					nID 20.0

Region / Sub	South Agassiz / Tamarack	**Sample Size**	10
Component	Late Woodland	**Diversity**	4
Reference	Florin and Wergin 2004	**Use Pattern**	P?

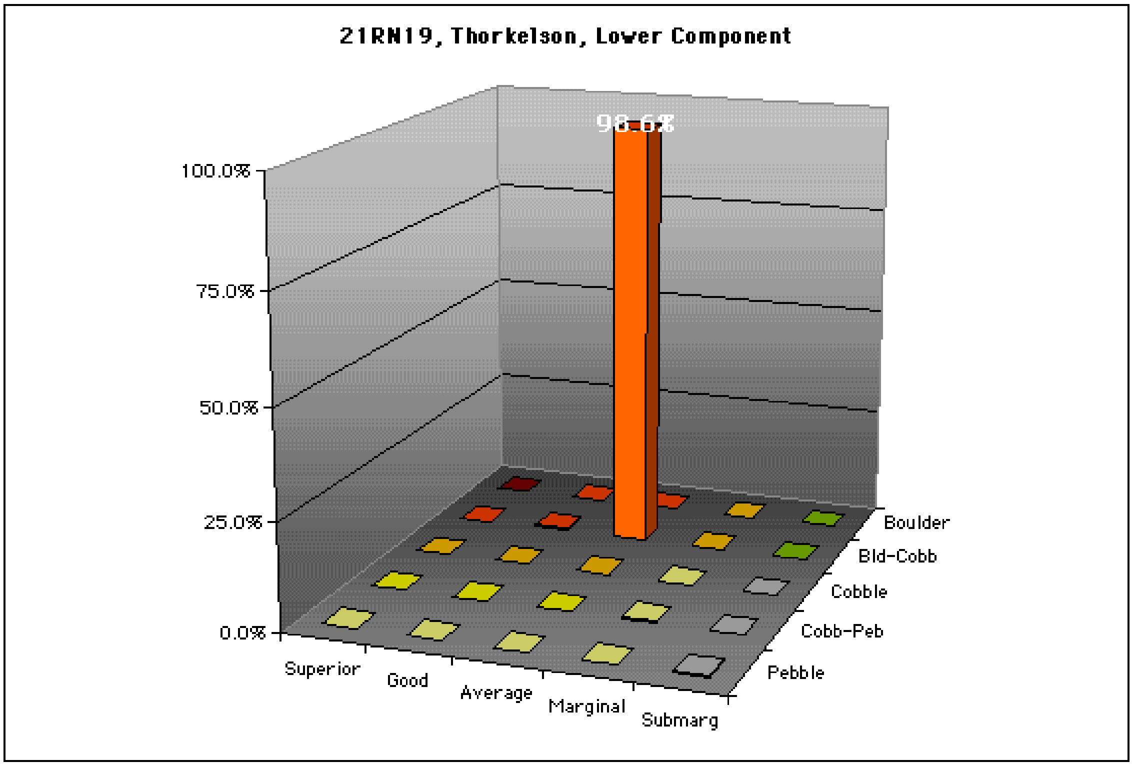
Appendix 2. 21PL85 (lower component, cf. Archaic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 96.6				
Cobble					
Cobble-Pebble					
Pebble					nID 3.4

Region / Sub	South Agassiz / Tamarack	**Sample Size**	59
Component	Archaic?	**Diversity**	2
Reference	Florin and Wergin 2004	**Use Pattern**	C?

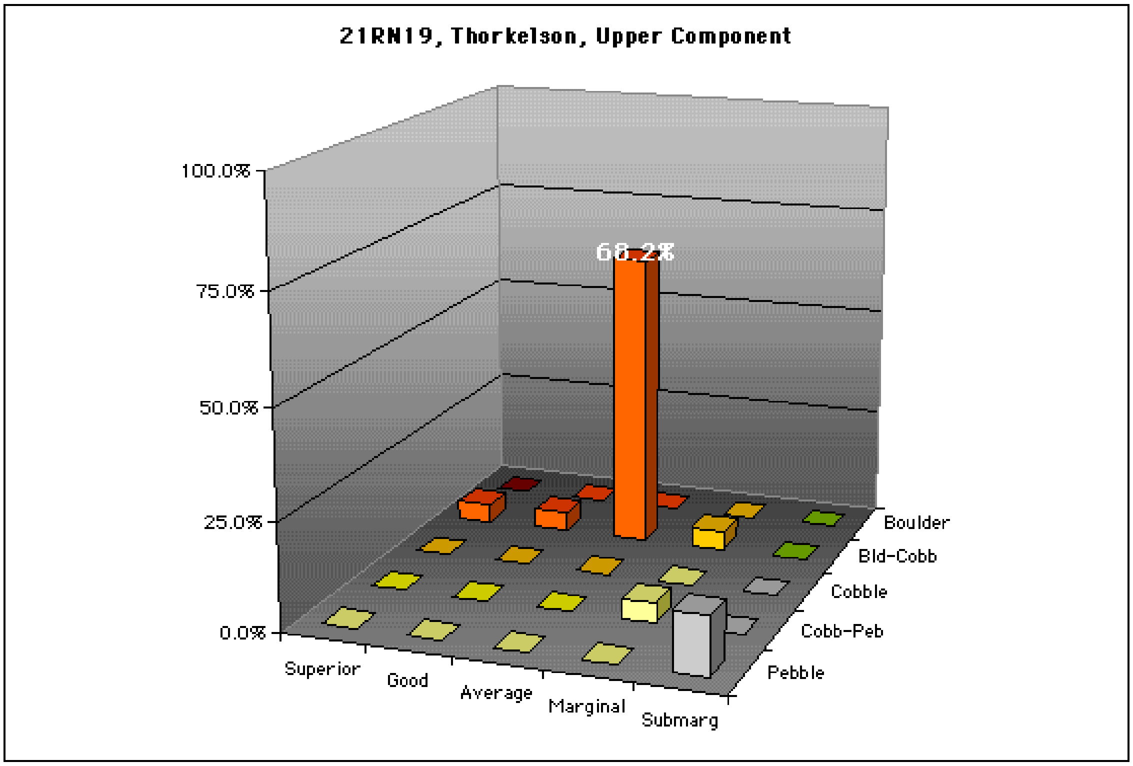
Appendix 2. 21RN19, Thorkelson (lower).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble		GFS 0.4 CVC 0.4	SRC 98.6		
Cobble					
Cobble-Pebble				Quartz 0.4	
Pebble					nID 0.4

Region / Sub	South Agassiz / Shetek	**Sample Size**	279
Component		**Diversity**	5
Reference	Gonsior and Yourd 1990	**Use Pattern**	B

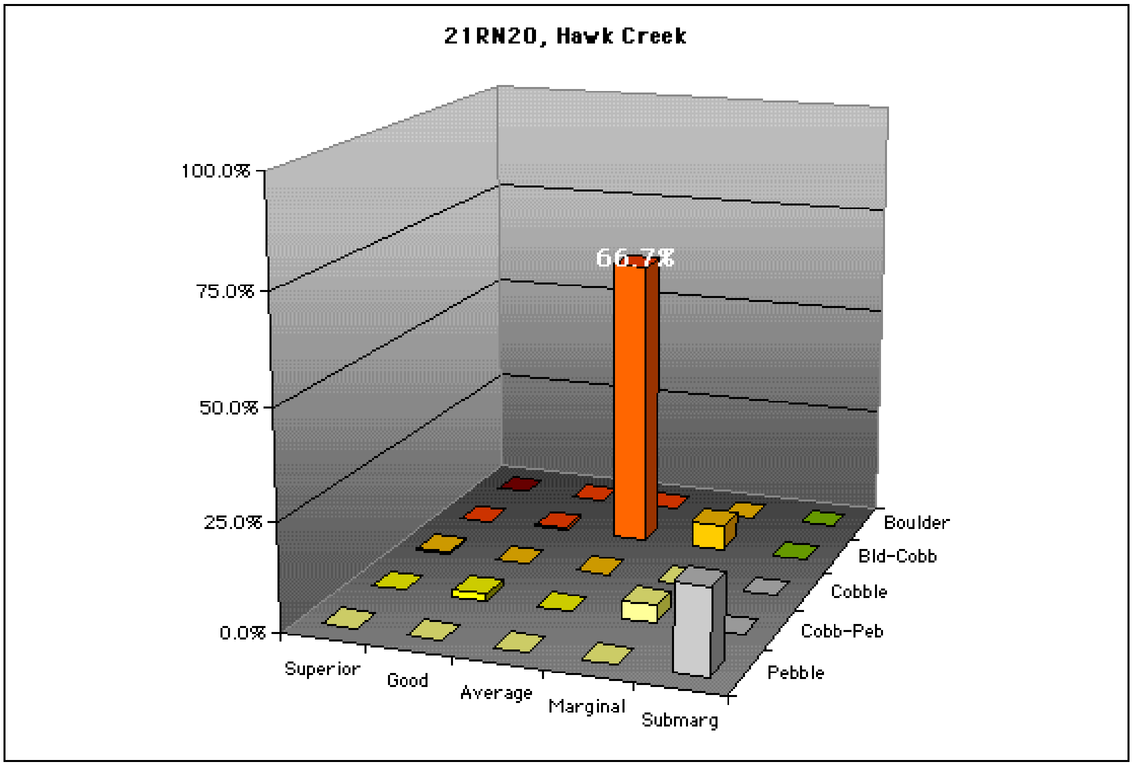
Appendix 2. 21RN19, Thorkelson (upper).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 4.5	GFS 4.5	SRC 68.2	TRS 4.5	
Cobble					
Cobble-Pebble				Quartz 4.5	
Pebble					nID 13.6

Region / Sub	South Agassiz / Shetek	**Sample Size**	22
Component		**Diversity**	7
Reference	Gonsior and Yourd 1990	**Use Pattern**	C?

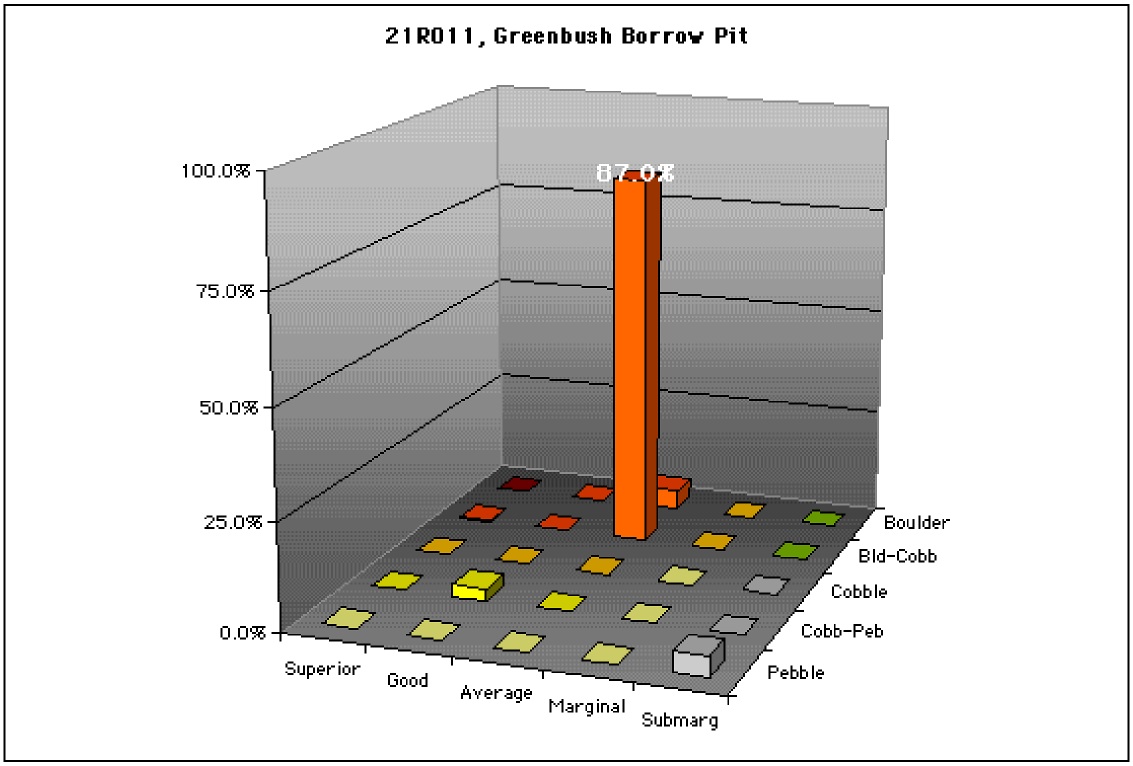
Appendix 2. 21RN20, Hawk Creek.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 0.3		
Boulder-Cobble		Galena 0.3 GFS 0.5	SRC 64.8 PdC 1.9	TRS 6.1	
Cobble					
Cobble-Pebble	GMC 0.8	RRC 1.6		Quartz 4.0	
Pebble					nID 19.8

Region / Sub	South Agassiz / Shetek	**Sample Size**	375
Component		**Diversity**	14
Reference	Gonsior and Yourd 1990	**Use Pattern**	C

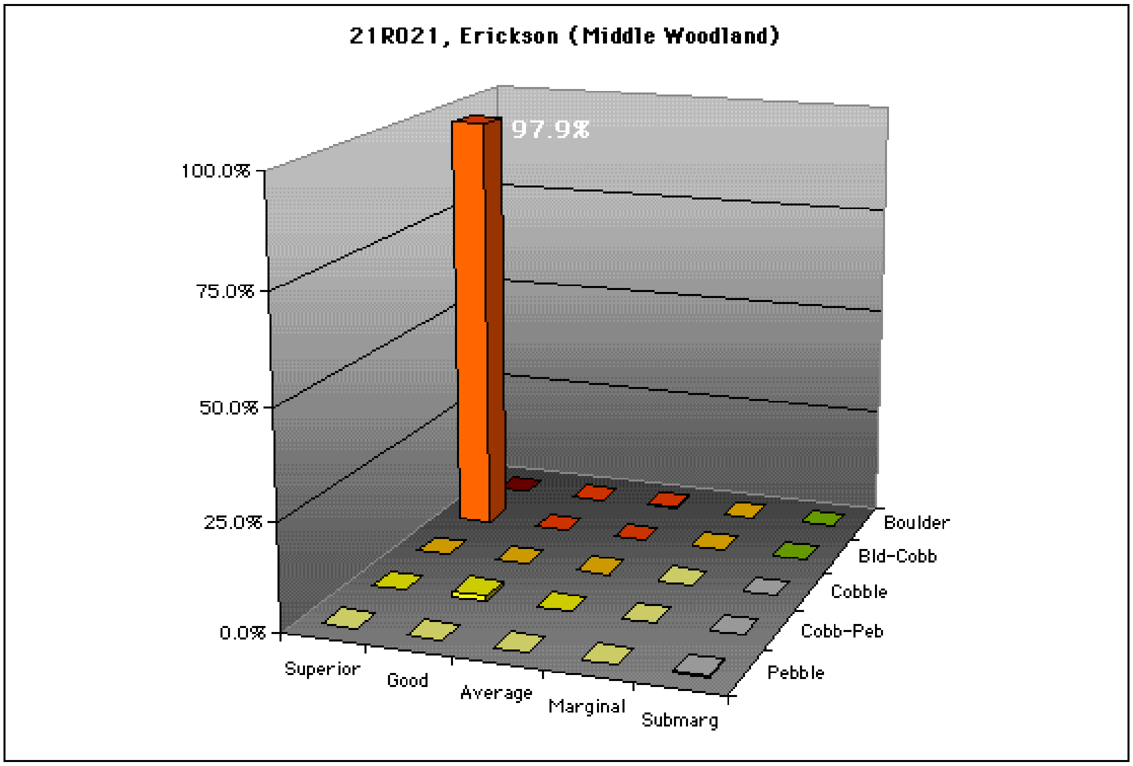
Appendix 2. 21RO11, Greenbush Borrow Pit.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 4.7		
Boulder-Cobble	KRF 0.2		SRC 87.0		
Cobble					Basaltic 0.4
Cobble-Pebble		RRC 2.9		Quartz < 0.1	
Pebble					

Region / Sub	South Agassiz / Tamarack	**Sample Size**	4,238
Component	Late Paleoindian	**Diversity**	10
Reference	Peterson 1973	**Use Pattern**	B

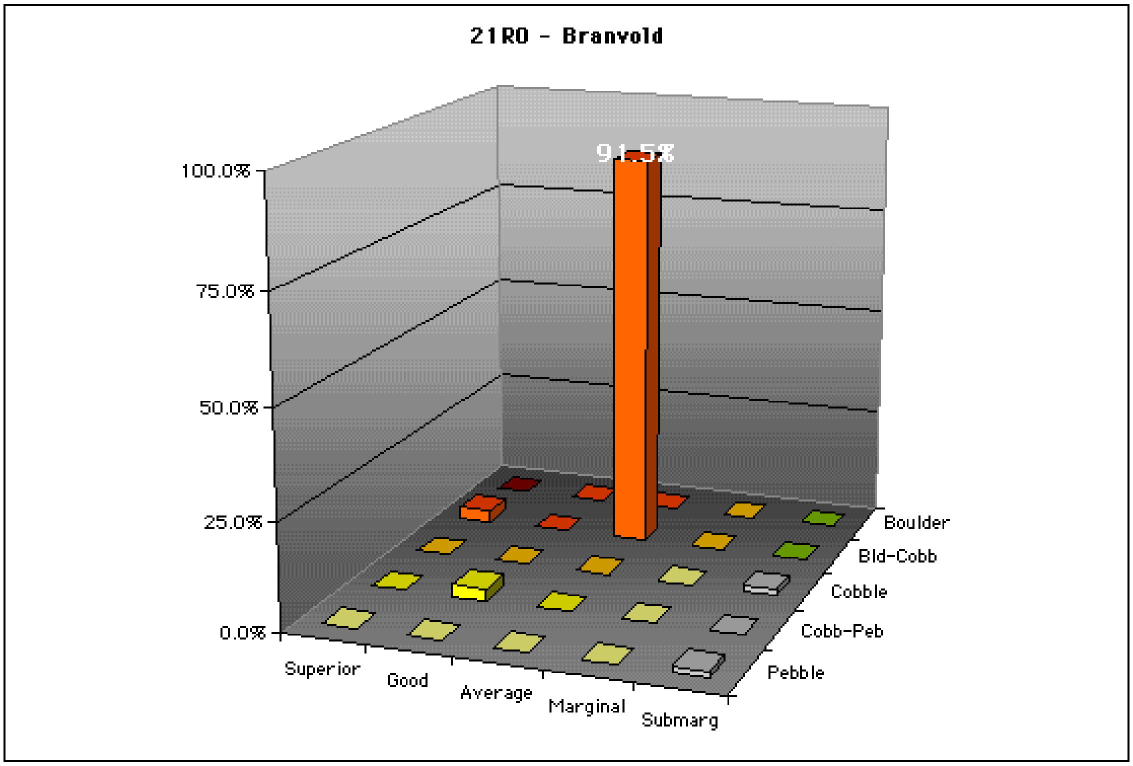
Appendix 2. 21RO21, Erickson.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder			LoWR 0.4		
Boulder-Cobble	KRF 97.9			TRS 0.1	
Cobble					
Cobble-Pebble		RRC 1.2			
Pebble					nID 0.4

Region / Sub	South Agassiz / Tamarack	**Sample Size**	561
Component	Middle Woodland (cf. Laurel)	**Diversity**	6
Reference	Bakken 1988	**Use Pattern**	C?

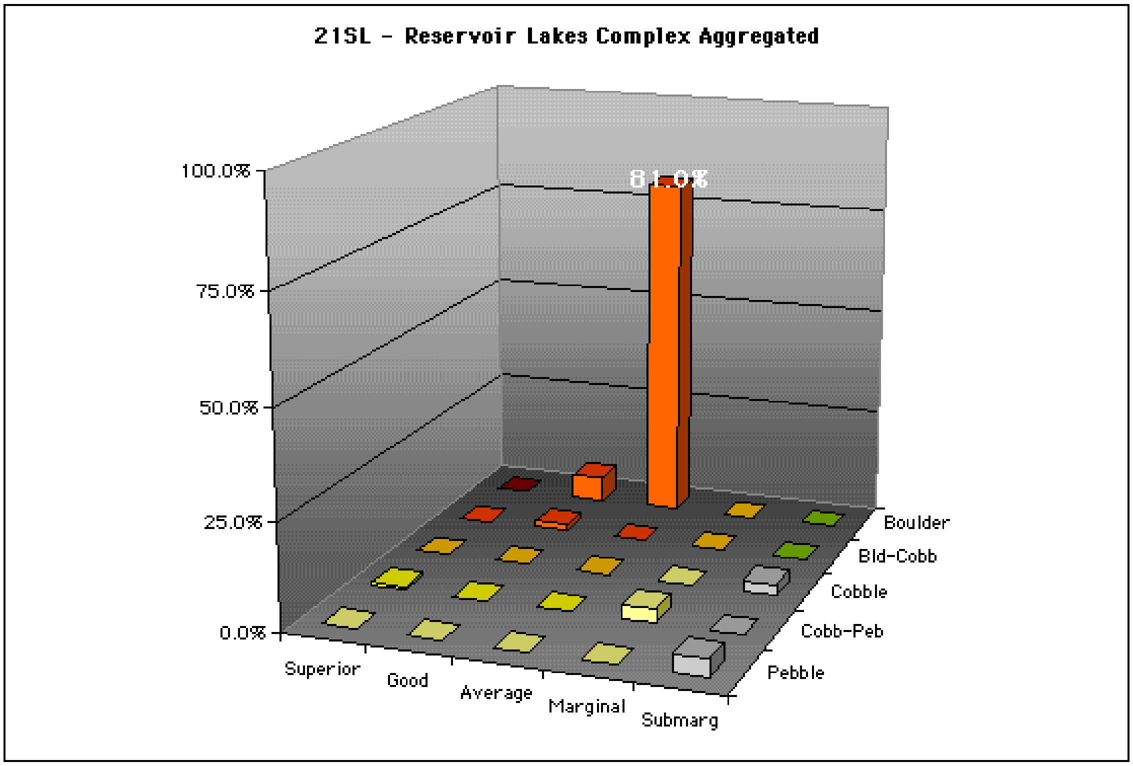
Appendix 2. 21RO, Branvold.



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 2.8		SRC 91.5		
Cobble					Basaltic 1.4
Cobble-Pebble		RRC 2.8			
Pebble					nID 1.4

Region / Sub	South Agassiz / Tamarack	**Sample Size**	71
Component	Late Paleoindian	**Diversity**	5
Reference	M. Magner, personal communication 1990	**Use Pattern**	B

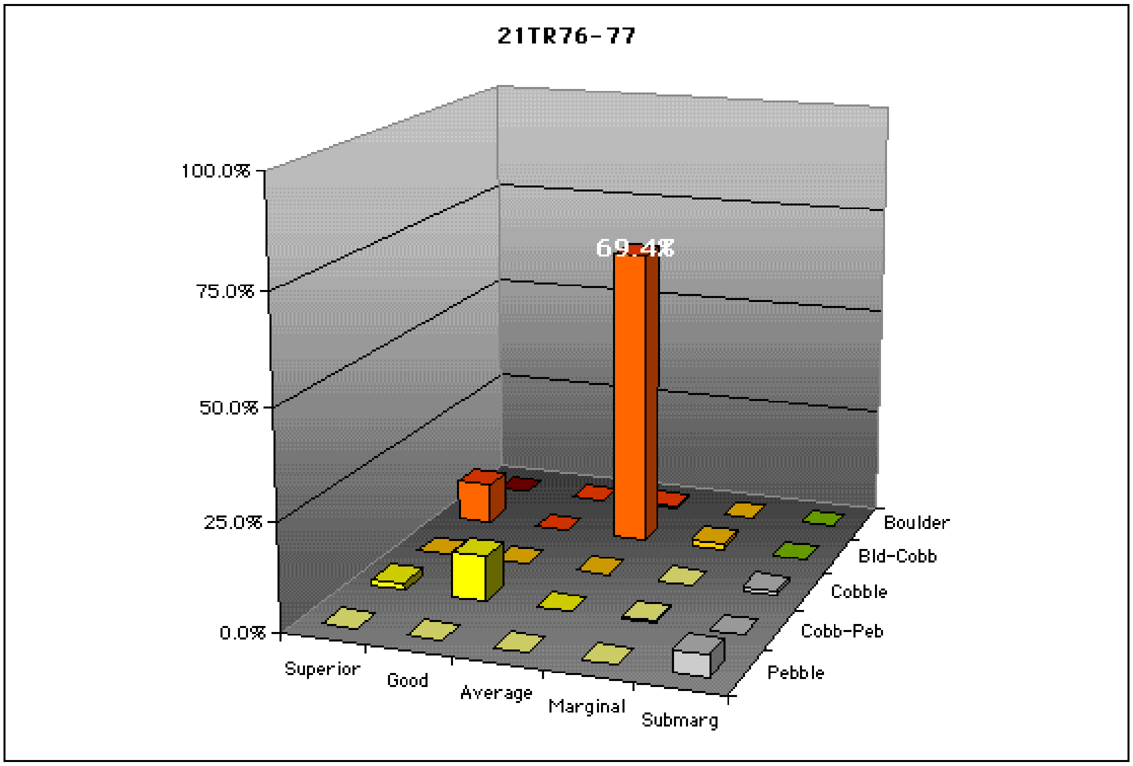
Appendix 2. 21SL, Reservoir Lakes Complex, aggregated.



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 5.9	KLS 81.0		
Boulder-Cobble		GFS 1.2 Kakabeka 0.4			
Cobble					Basaltic 2.0 Granitic 0.4 Oth chop 0.2
Cobble-Pebble	HBLC 0.8			Quartz 3.2	
Pebble					nID 4.2

Region / Sub	West Superior / Arrowhead	**Sample Size**	14,835
Component	Paleoindian (possibly elements of Early Archaic)	**Diversity**	16
Reference	Harrison et al. 1995	**Use Pattern**	B

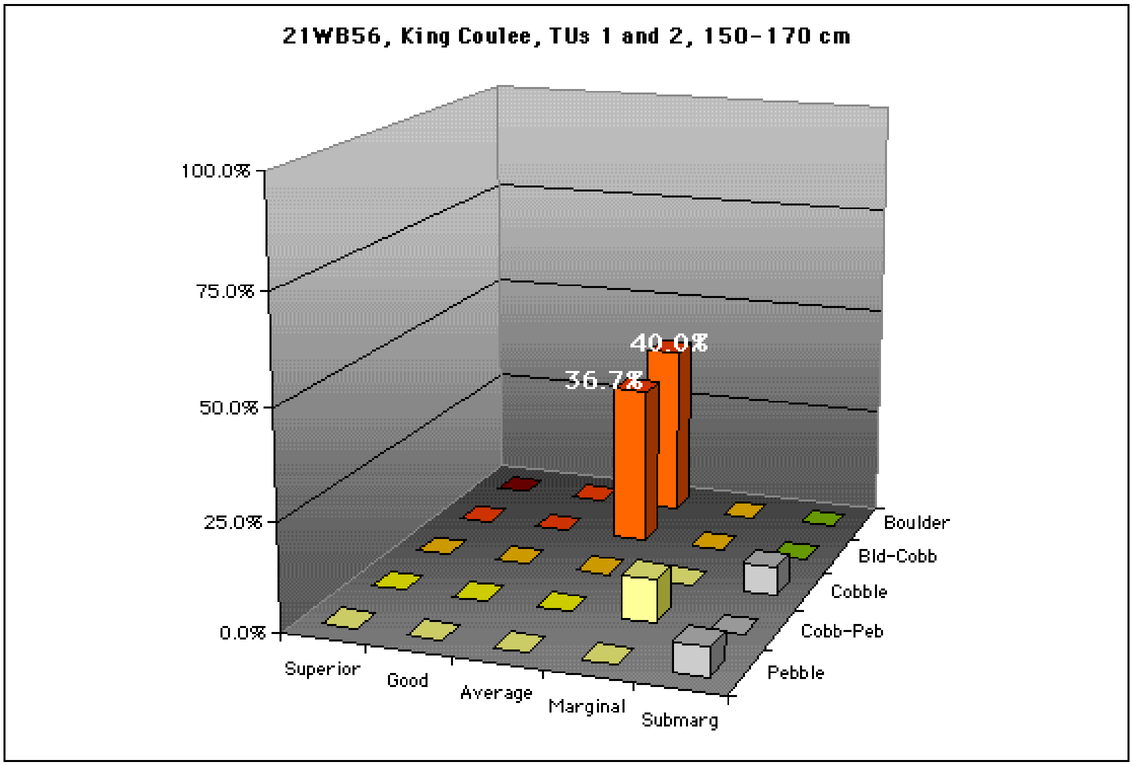
Appendix 2. 21TR76-77.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 0.6		
Boulder-Cobble	KRF 9.4		SRC 69.4	TRS 1.7	
Cobble					Basaltic 0.6 Granitic 0.6
Cobble-Pebble	HBLC 1.7	RRC 10.6		Quartz 0.6	
Pebble					nID 5.0

Region / Sub	South Agassiz / Upper Red	**Sample Size**	180
Component	Late Paleoindian	**Diversity**	11
Reference	Forsberg et al. 1999	**Use Pattern**	B?

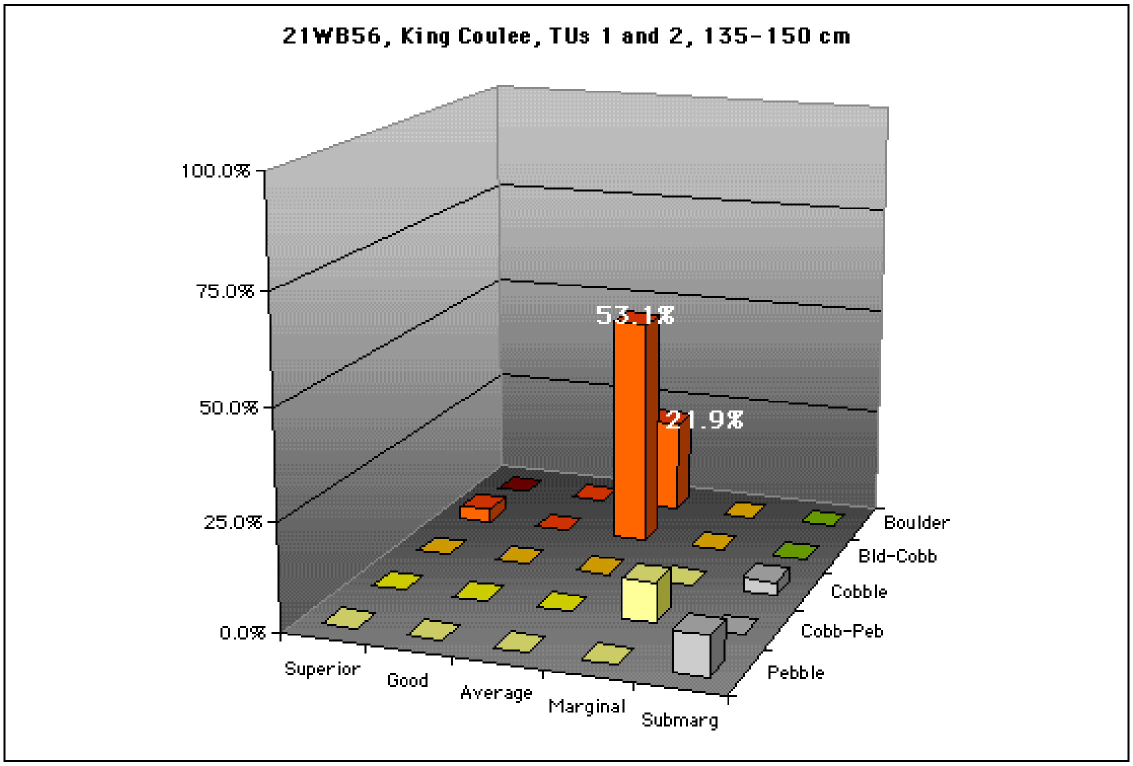
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 150-170 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 40.0		
Boulder-Cobble			PdC 36.7		
Cobble					Basaltic 6.7
Cobble-Pebble				Quartz 10.0	
Pebble					nID 6.7

Region / Sub	Hollandale	**Sample Size**	30
Component	*150-170 cm*	**Diversity**	6
Reference	Perkl 1996, 2002	**Use Pattern**	?

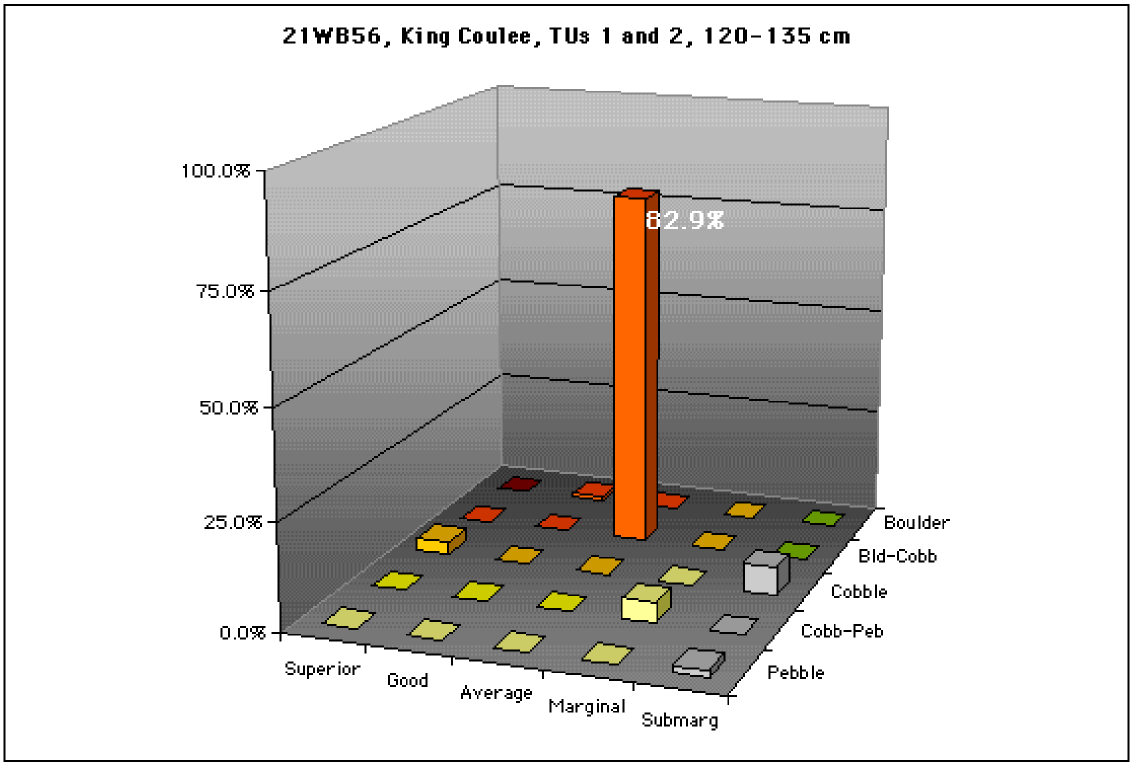
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 135-150 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 21.9		
Boulder-Cobble	KRF 3.1		PdC 53.1		
Cobble					Basaltic 3.1
Cobble-Pebble				Quartz 9.4	
Pebble					nID 9.4

Region / Sub	Hollandale	**Sample Size**	32
Component	*135-150 cm*	**Diversity**	6
Reference	Perkl 1996, 2002	**Use Pattern**	?

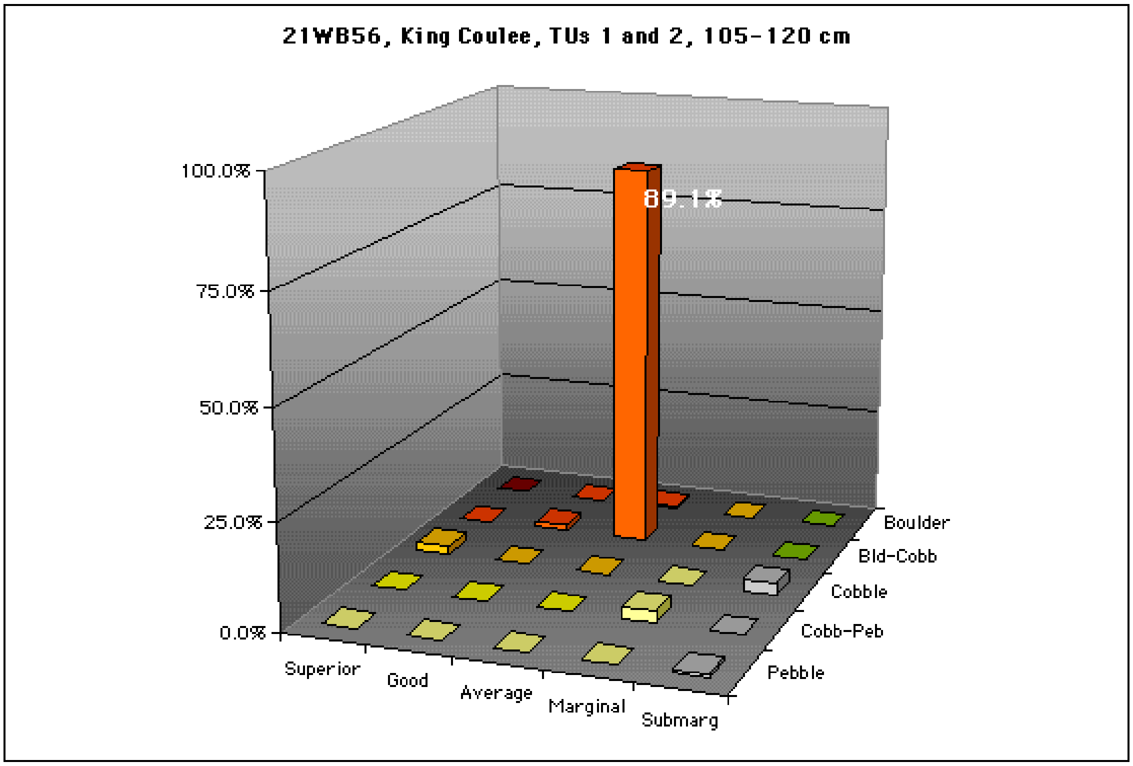
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 120-155 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 0.8			
Boulder-Cobble			PdC 82.9		
Cobble	GMC 3.3				Basaltic 6.5
Cobble-Pebble				Quartz 4.9	
Pebble					nID 1.6

Region / Sub	Hollandale	**Sample Size**	123
Component	*120-135 cm*	**Diversity**	6
Reference	Perkl 1996, 2002	**Use Pattern**	?

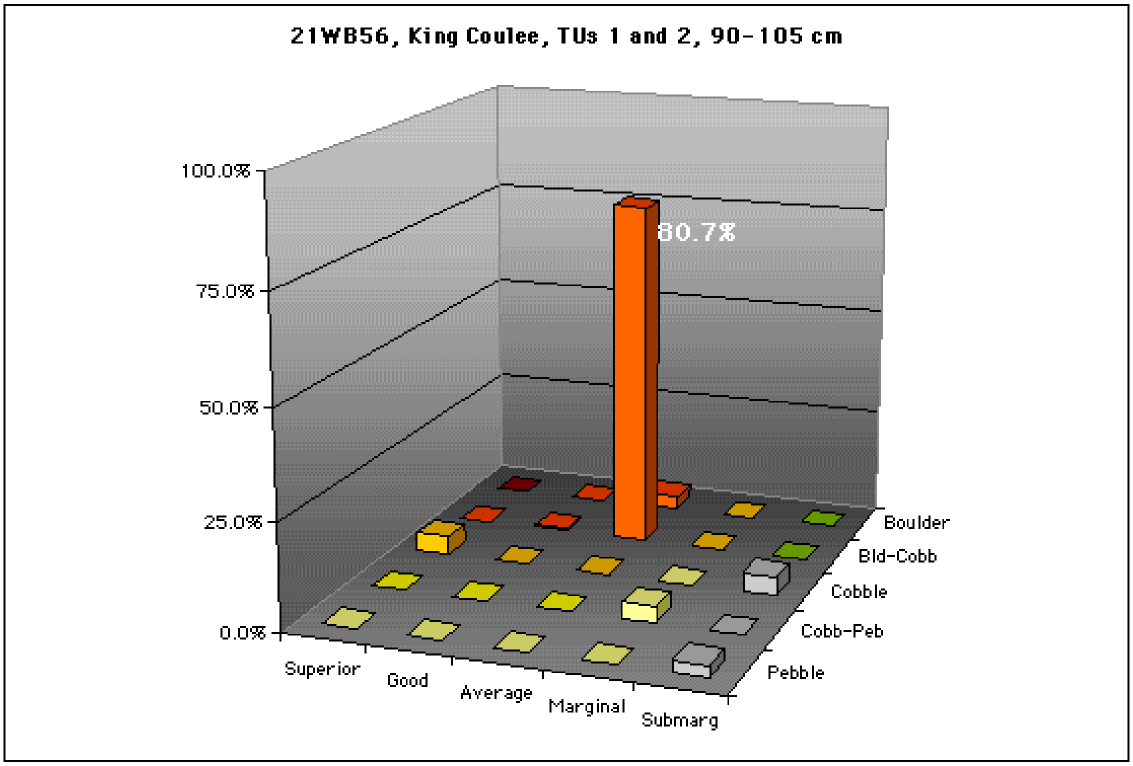
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 105-120 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 0.7		
Boulder-Cobble		CVC 1.5	PdC 89.1		
Cobble	GMC 2.2				Basaltic 2.9
Cobble-Pebble				Quartz 2.9	
Pebble					nID 0.7

Region / Sub	Hollandale	**Sample Size**	137
Component	*105-120 cm*	**Diversity**	7
Reference	Perkl 1996, 2002	**Use Pattern**	?

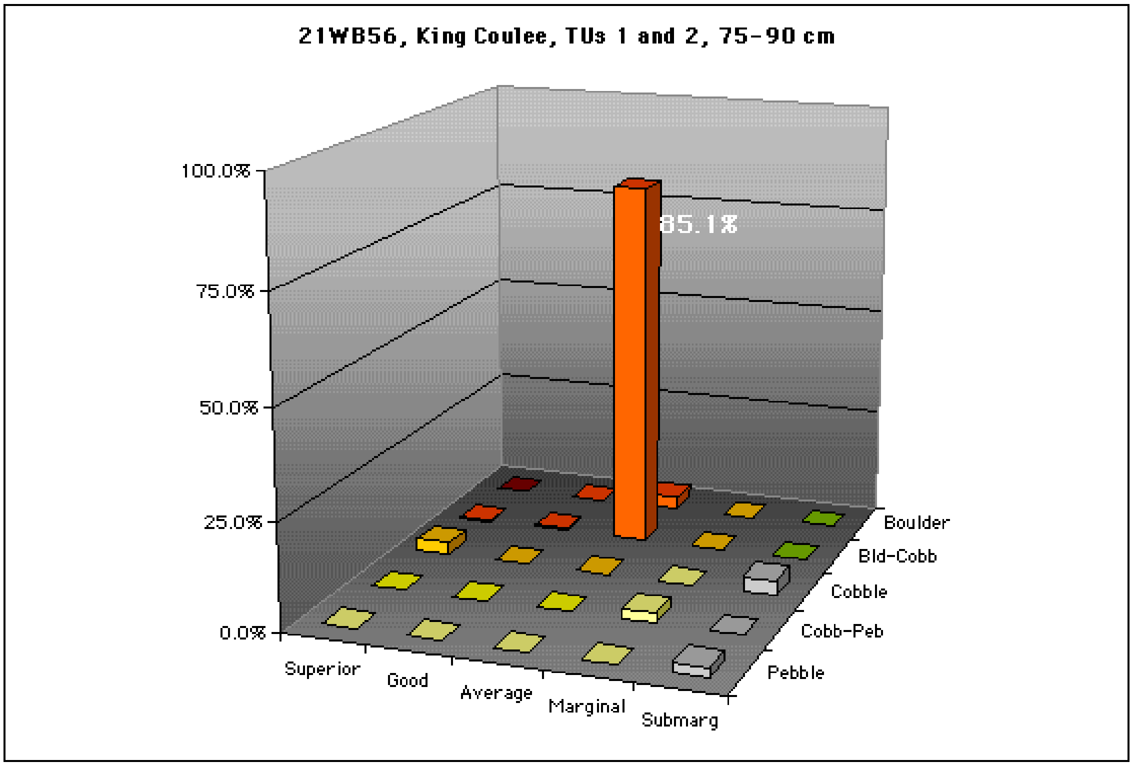
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 90-105 cm.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder			Hixton Grp 3.3		
Boulder-Cobble		Galena 0.6	PdC 80.7		
Cobble	GMC 4.4				Basaltic 4.4
Cobble-Pebble				Quartz 3.9	
Pebble					nID 2.8

Region / Sub	Hollandale	**Sample Size**	181
Component	*90-105 cm*	**Diversity**	10
Reference	Perkl 1996, 2002	**Use Pattern**	?

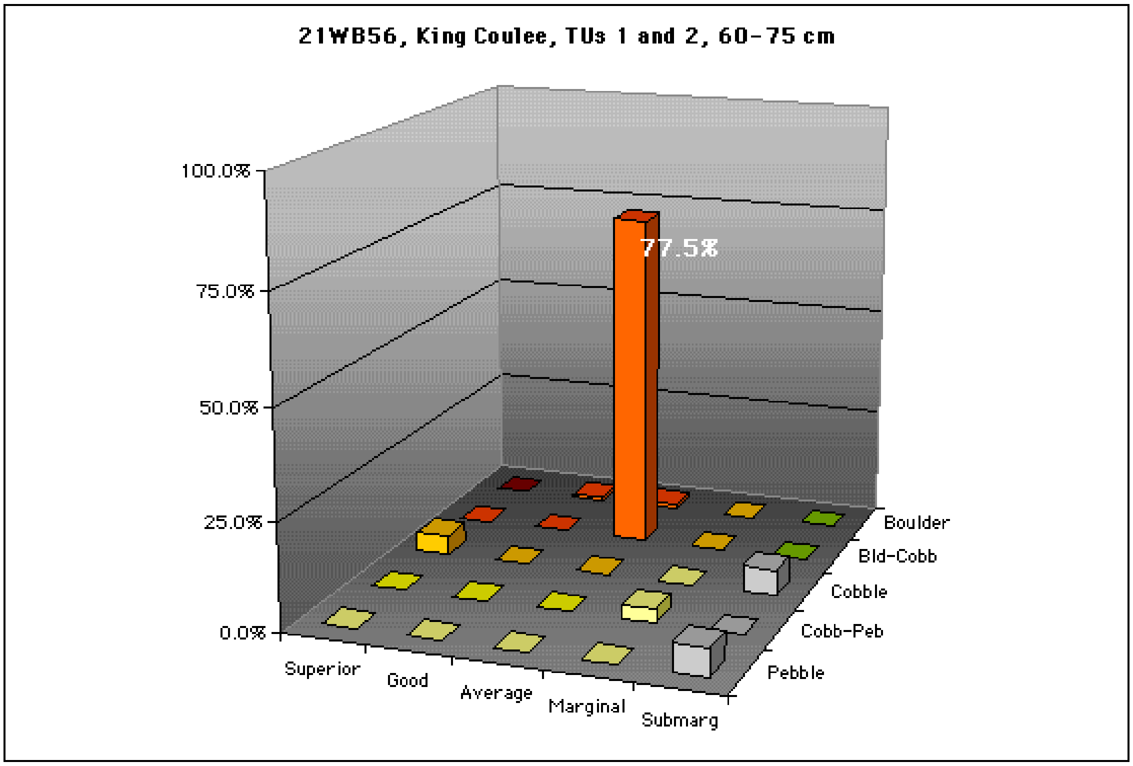
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 75-90 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 2.9		
Boulder-Cobble	KRF 0.3	CVC 0.6	PdC 85.1		
Cobble	GMC 2.9				Basaltic 3.2 Granitic 0.3
Cobble-Pebble				Quartz 2.3	
Pebble					nID 2.3

Region / Sub	Hollandale	**Sample Size**	342
Component	*75-90 cm*	**Diversity**	11
Reference	Perkl 1996, 2002	**Use Pattern**	?

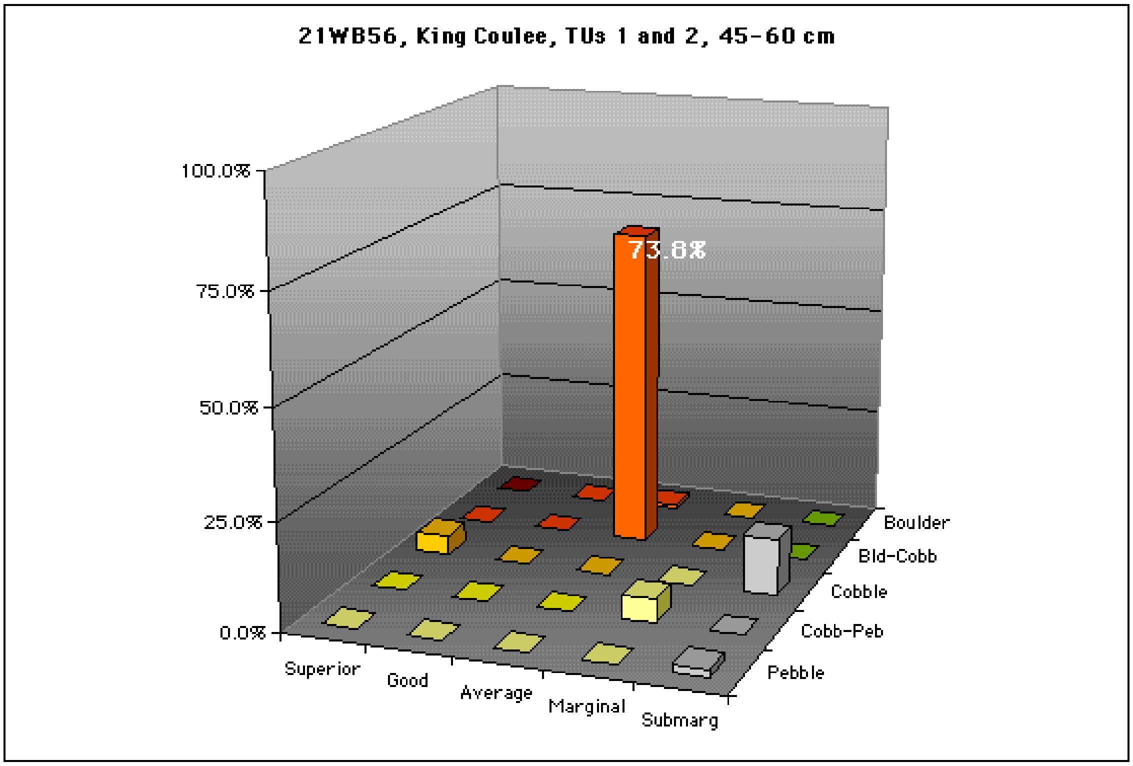
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 60-75 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 0.7	Hixton Grp 1.3		
Boulder-Cobble			PdC 77.5		
Cobble	GMC 4.6				Basaltic 6.0
Cobble-Pebble				Quartz 3.3	
Pebble					nID 6.6

Region / Sub	Hollandale	**Sample Size**	151
Component	*60-75 cm*	**Diversity**	9
Reference	Perkl 1996, 2002	**Use Pattern**	?

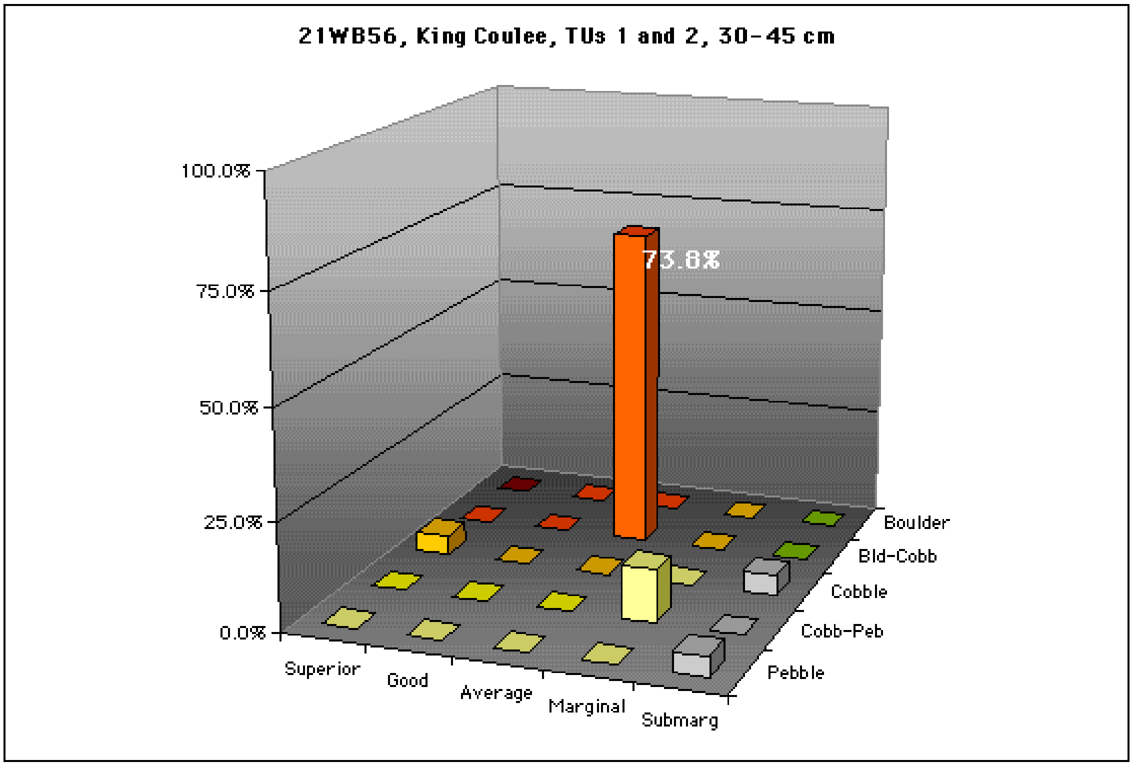
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 45-60 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 0.9		
Boulder-Cobble			PdC 73.8		
Cobble	GMC 4.7				Basaltic 13.1
Cobble-Pebble				Quartz 5.6	
Pebble					nID 1.9

Region / Sub	Hollandale	**Sample Size**	107
Component	*45-60 cm*	**Diversity**	7
Reference	Perkl 1996, 2002	**Use Pattern**	?

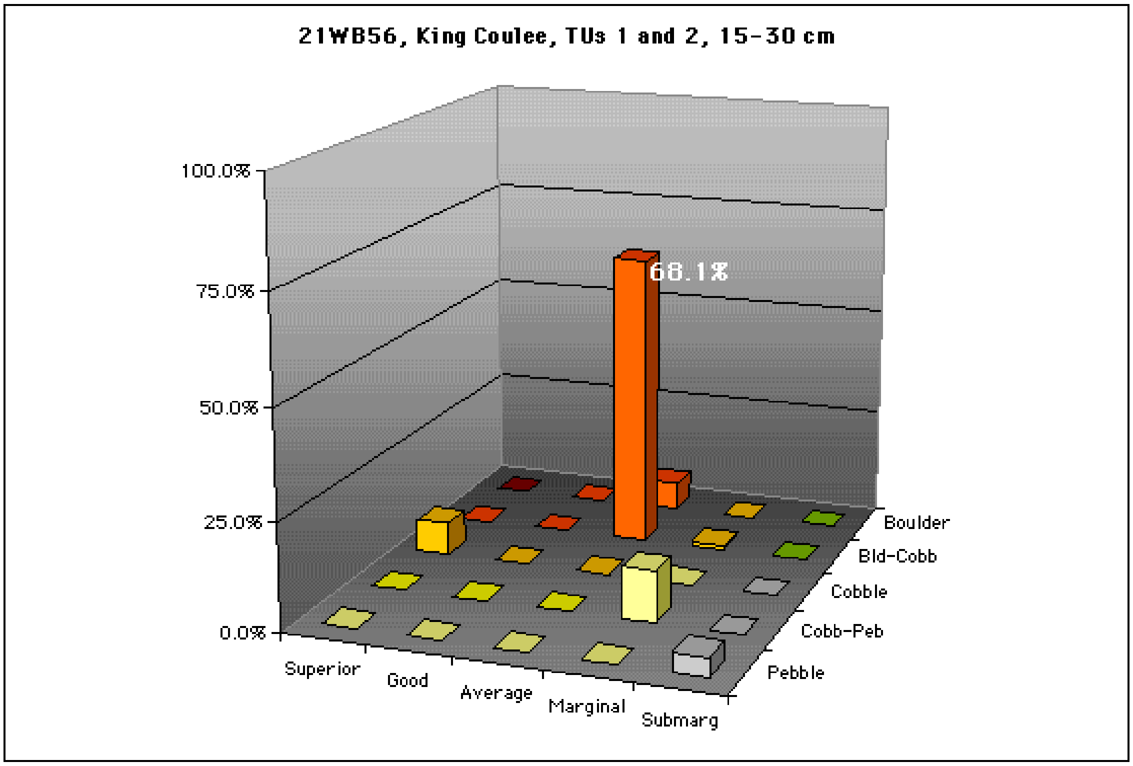
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 30-45 cm.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder					
Boulder-Cobble			PdC 73.8		
Cobble	GMC 4.6				Basaltic 4.6
Cobble-Pebble				Quartz 12.3	
Pebble					nID 4.6

Region / Sub	Hollandale	**Sample Size**	65
Component	*30-45 cm*	**Diversity**	6
Reference	Perkl 1996, 2002	**Use Pattern**	?

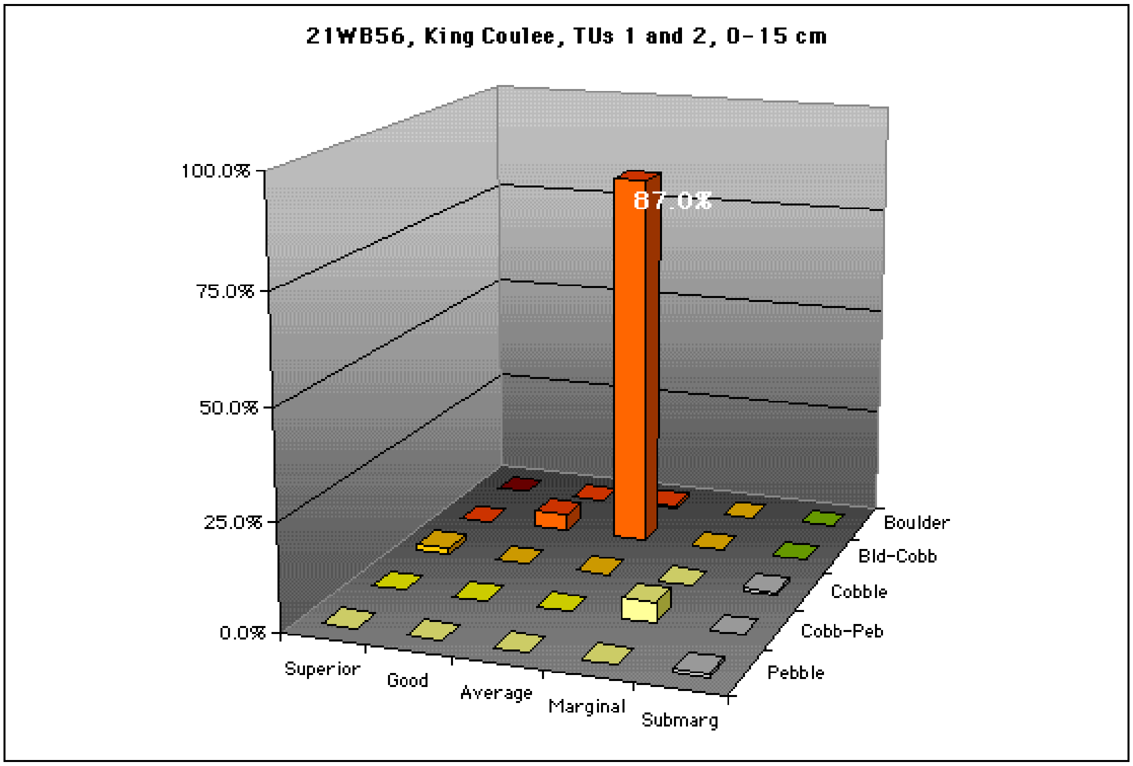
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 15-30 cm.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder			Hixton Grp 6.6		
Boulder-Cobble			PdC 68.1	TRS 1.1	
Cobble	GMC 7.7				
Cobble-Pebble				Quartz 12.1	
Pebble					nID 4.4

Region / Sub	Hollandale	**Sample Size**	91
Component	*15-30 cm*	**Diversity**	7
Reference	Perkl 1996, 2002	**Use Pattern**	?

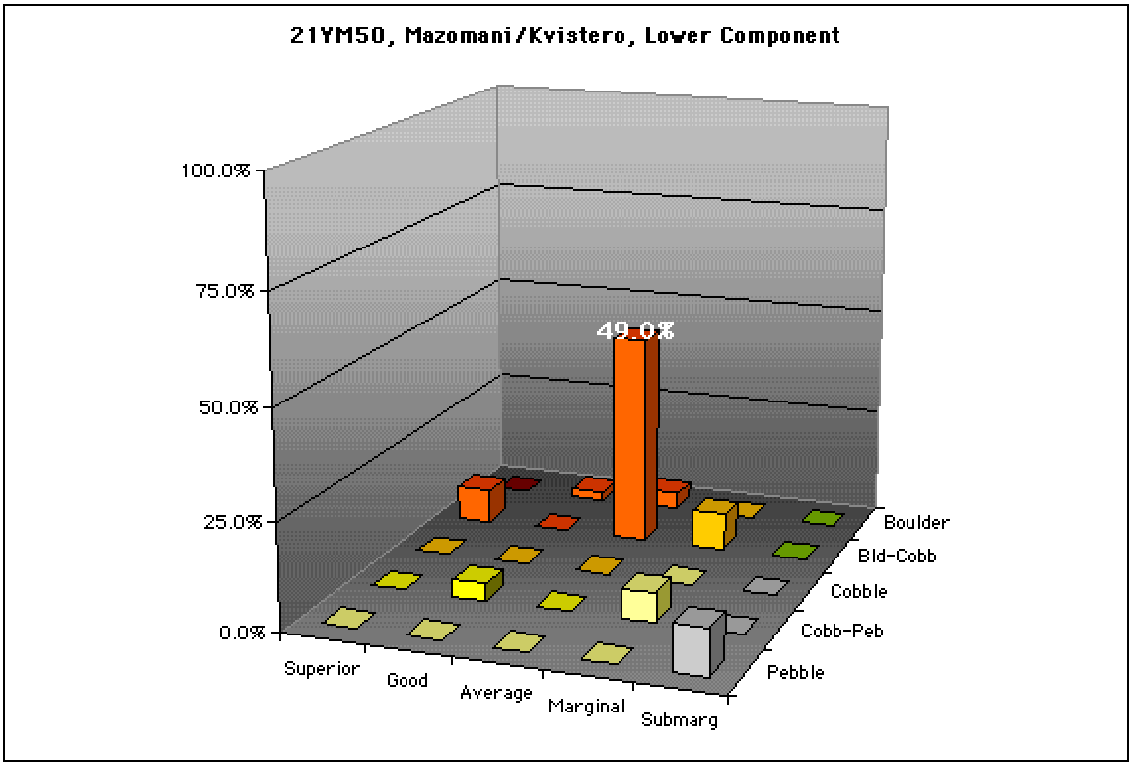
Appendix 2. 21WB56, King Coulee, TUs 1 and 2, 0-15 cm.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 0.8		
Boulder-Cobble		Galena 4.1	PdC 87.0		
Cobble	GMC 1.6				Basaltic 0.8
Cobble-Pebble				Quartz 4.9	
Pebble					nID 0.8

Region / Sub	Hollandale	**Sample Size**	123
Component	*0-15 cm*	**Diversity**	7
Reference	Perkl 1996, 2002	**Use Pattern**	?

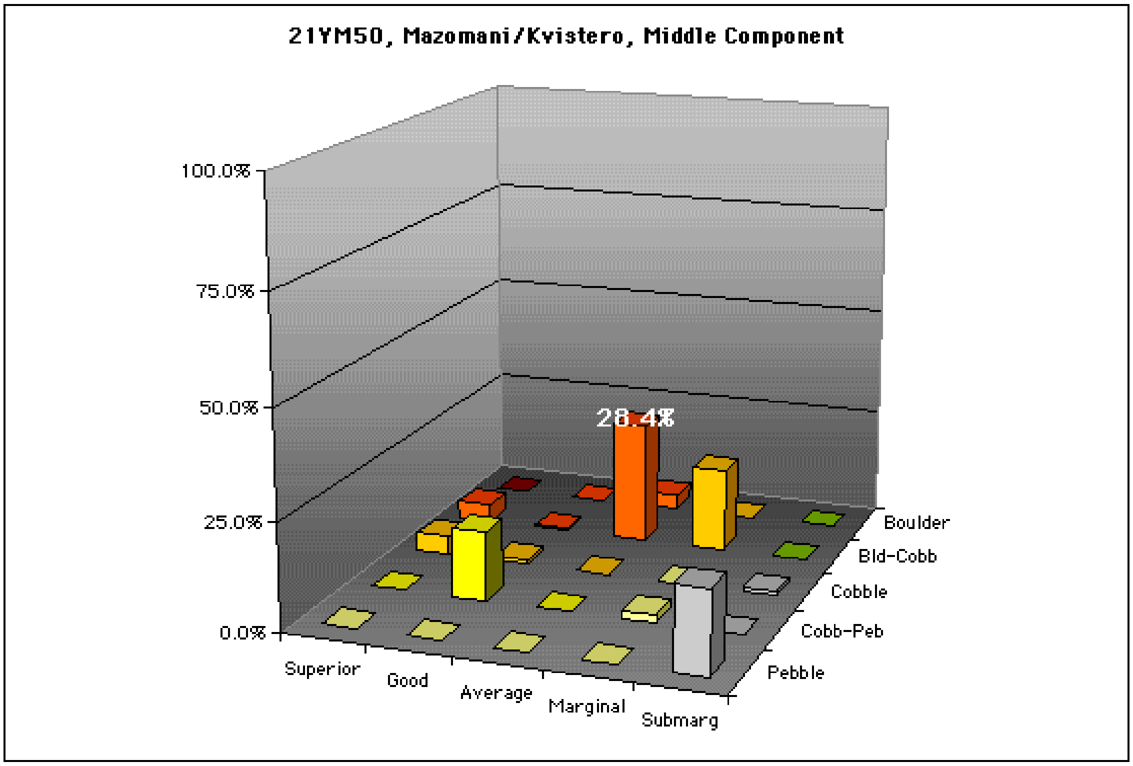
Appendix 2. 21YM50, Mazomani/Kvistero Homesite (lower).



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 2.0	LoWR 3.9		
Boulder-Cobble	Burlington 2.0 KRF 5.9		PdC 30.4 SRC 18.6	TRS 8.8	
Cobble					
Cobble-Pebble		RRC 3.9		Quartz 6.9	
Pebble					nID 10.8

Region / Sub	South Agassiz / Shetek	**Sample Size**	102
Component	Lower	**Diversity**	12
Reference	Gonsior et al. 1996	**Use Pattern**	C?

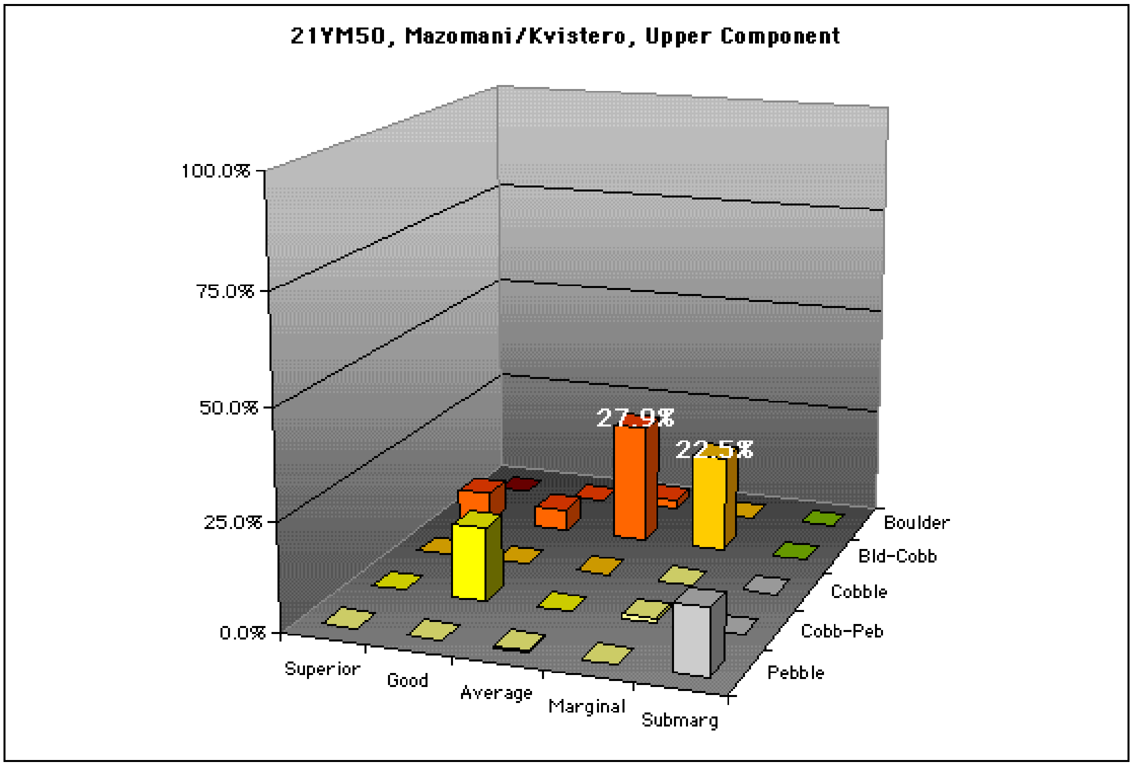
Appendix 2. 21YM50, Mazomani/Kvistero Homesite (middle).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			KLS 0.5 LoWR 3.0		
Boulder-Cobble	Burlington 1.0 KRF 3.5	GFS 0.5	PdC 5.5 SRC 22.9	TRS 19.4	
Cobble	GMC 4.5	Fusil Grp 1.0			Basaltic 1.0
Cobble-Pebble		RRC 15.9		Quartz 2.0	
Pebble					nID 19.4

Region / Sub	South Agassiz / Shetek	**Sample Size**	201
Component	Middle	**Diversity**	17
Reference	Gonsior et al. 1996	**Use Pattern**	C?

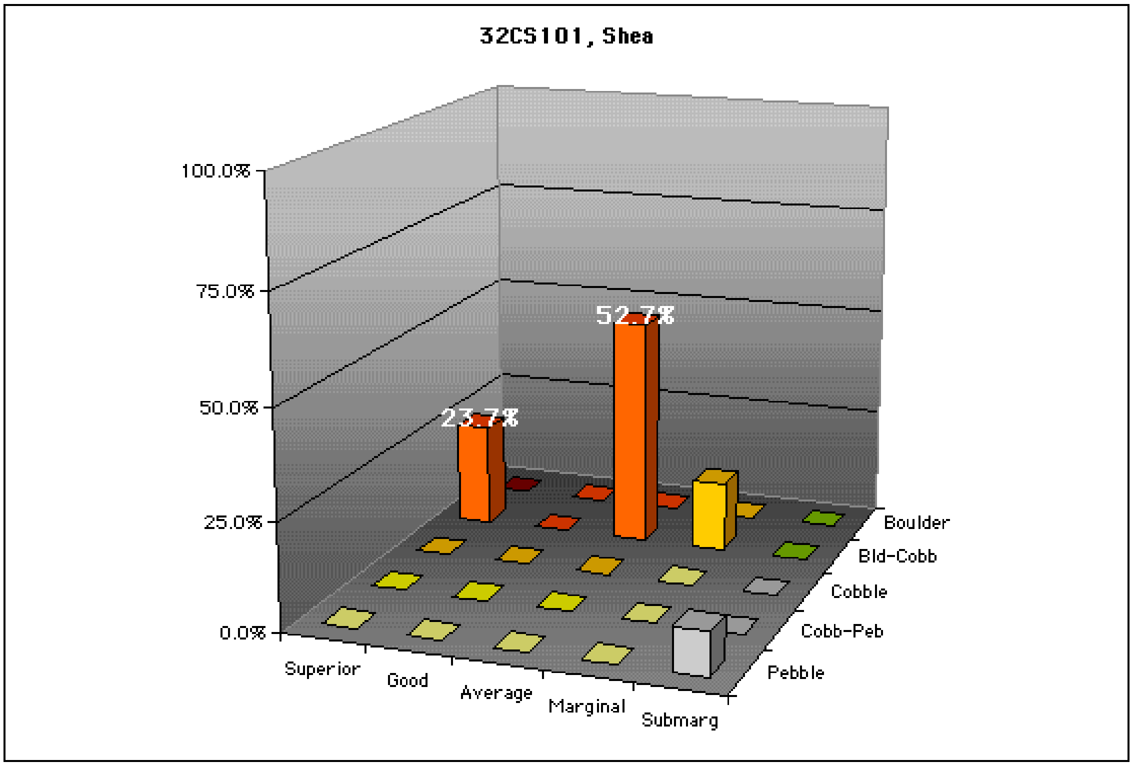
Appendix 2. 21YM50, Mazomani/Kvistero Homesite (upper).



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 2.3		
Boulder-Cobble	Burlington 0.4 KRF 6.9	CVC 3.4 GFS 1.9	PdC 1.1 SRC 26.7	TRS 22.5	
Cobble					Basaltic 0.4
Cobble-Pebble		RRC 17.2		Quartz 1.1	
Pebble					nID 15.7

Region / Sub	South Agassiz / Shetek	**Sample Size**	262
Component	Upper	**Diversity**	19
Reference	Gonsior et al. 1996	**Use Pattern**	C?

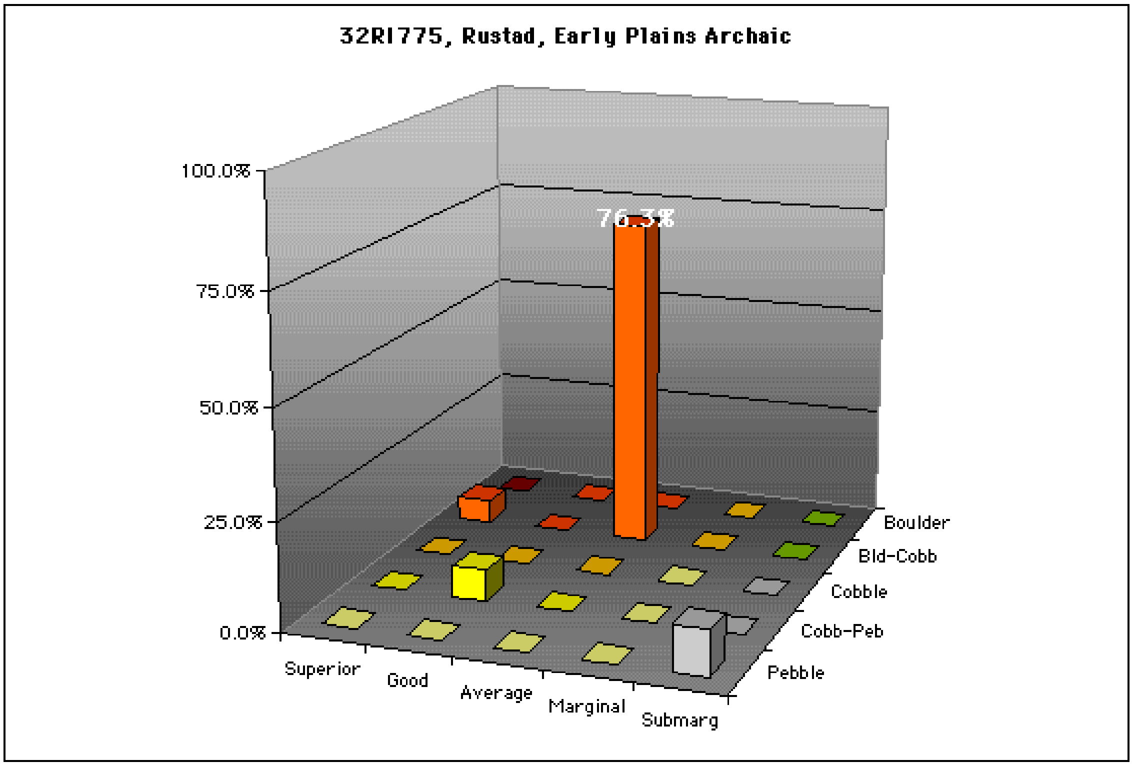
Appendix 2. 32CS101, Shea.



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 23.7		SRC 35.2	TRS 13.2	
Cobble					
Cobble-Pebble				Quartz 0.2	
Pebble					nID 27.7

Region / Sub	South Agassiz / Upper Red	**Sample Size**	1,789
Component		**Diversity**	**8**
Reference	Michlovic and Schneider 1988, 1993	**Use Pattern**	S

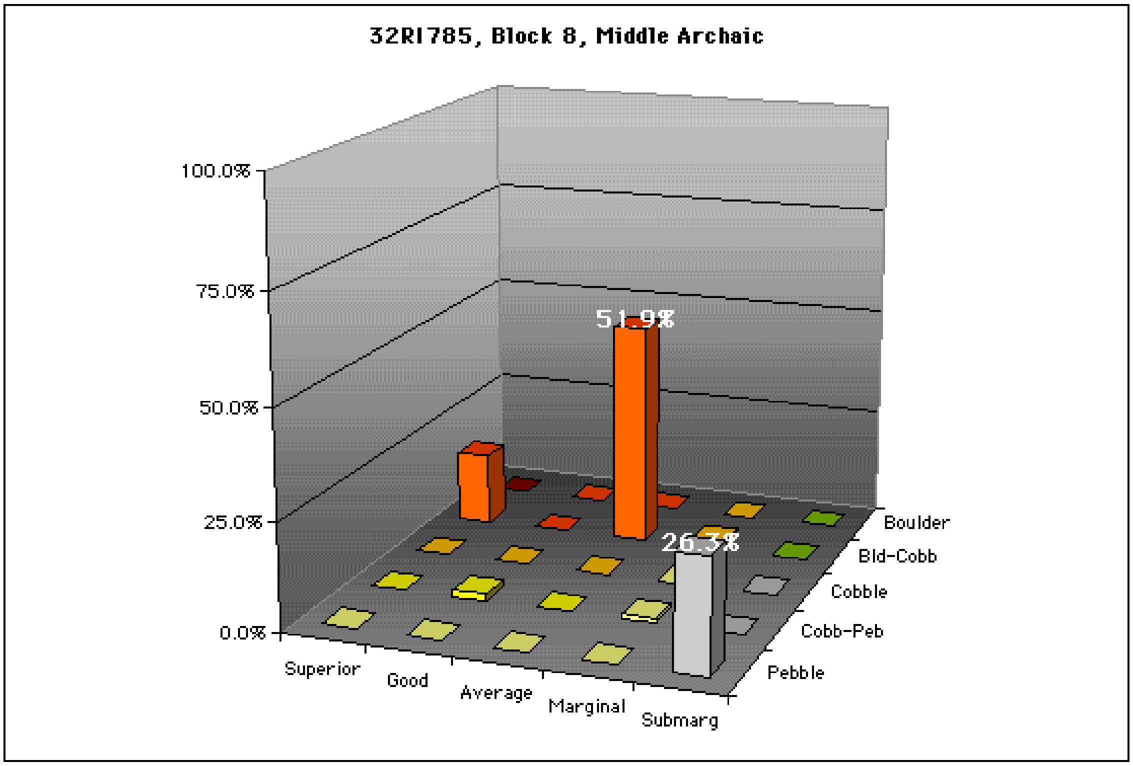
Appendix 2. 32RI775, Rustad (Early Plains Archaic).



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder	Obsidian < 0.1		LoWR < 0.1		
Boulder-Cobble	KRF 5.5		SRC 76.3	TRS 0.1	
Cobble					Basaltic < 0.1
Cobble-Pebble	HBLC < 0.1	RRC 7.3		Quartz < 0.1	
Pebble					nID 10.7

Region / Sub	South Agassiz / Upper Red	**Sample Size**	6,985
Component	Early Plains Archaic	**Diversity**	12
Reference	Michlovic and Running 2003	**Use Pattern**	C

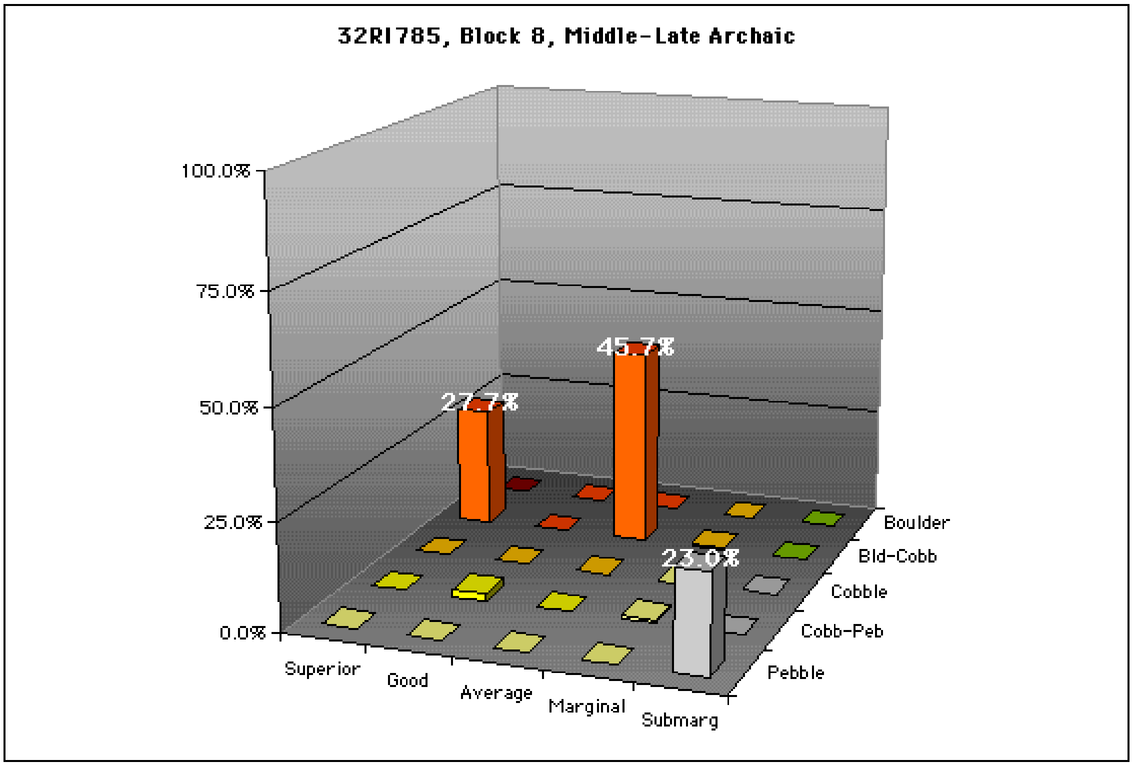
Appendix 2. 32RI785, Block 8 (Middle Archaic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 16.8		PdC 1.0 SRC 51.0	TRS 1.9	
Cobble					Basaltic 0.2
Cobble-Pebble		RRC 1.5		Quartz 1.2	
Pebble					nID 26.3

Region / Sub	South Agassiz / Upper Red	**Sample Size**	518
Component	Middle Archaic	**Diversity**	11
Reference	Dobbs 2001	**Use Pattern**	C

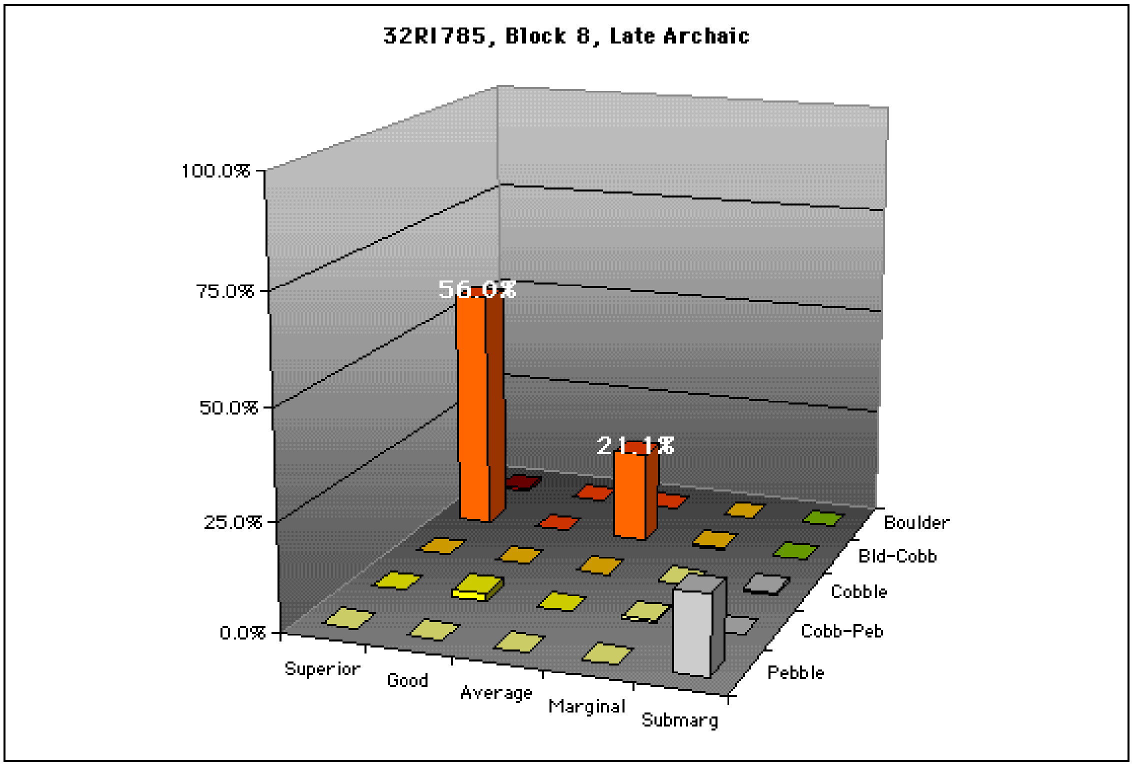
Appendix 2. 32RI785, Block 8 (Late to Middle Archaic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 27.7		PdC 0.7 SRC 45.0	TRS 0.7	
Cobble					Basaltic 0.4
Cobble-Pebble		RRC 1.8		Quartz 0.7	
Pebble					nID 23.0

Region / Sub	South Agassiz / Upper Red	**Sample Size**	278
Component	Late to Middle Archaic	**Diversity**	10
Reference	Dobbs 2001	**Use Pattern**	C

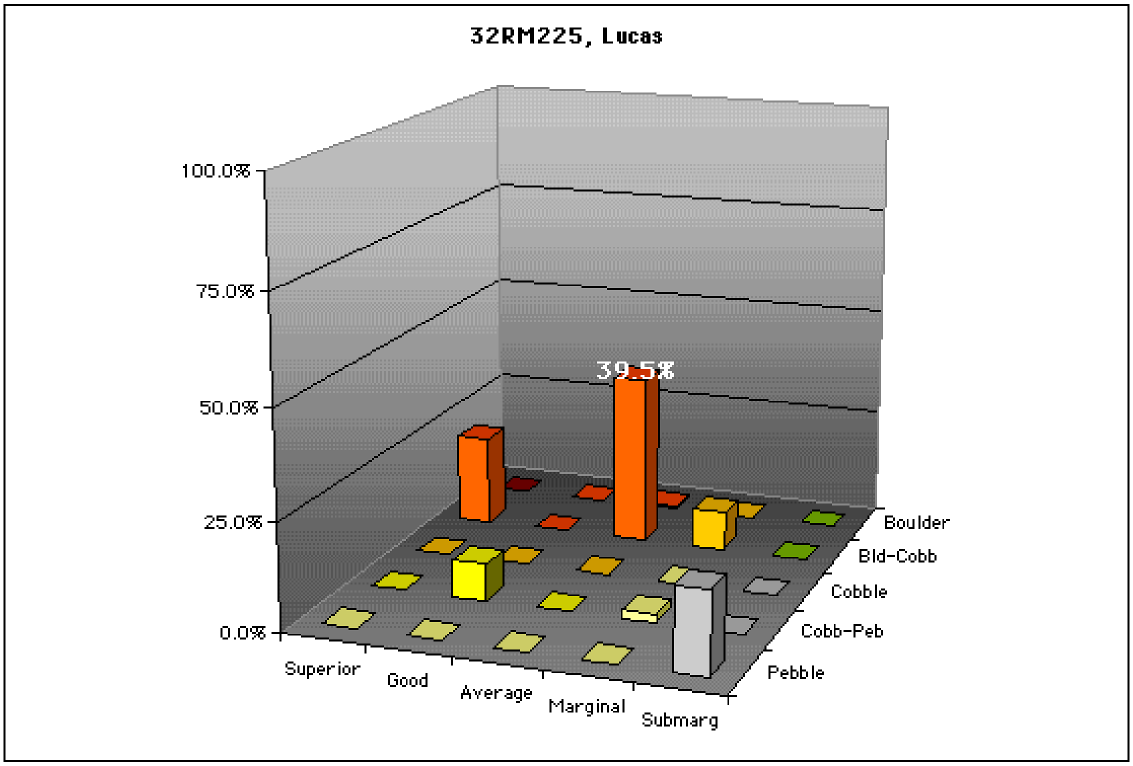
Appendix 2. 32RI785, Block 8 (Late Archaic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder	Obsidian 0.7				
Boulder-Cobble			PdC 0.2 SRC 20.9	TRS 0.7	
Cobble	KRF 56.0				Basaltic 0.7
Cobble-Pebble		RRC 1.7		Quartz 0.7	
Pebble					nID 18.3

Region / Sub	South Agassiz / Upper Red	**Sample Size**	459
Component	Late Archaic	**Diversity**	12
Reference	Dobbs 2001	**Use Pattern**	C

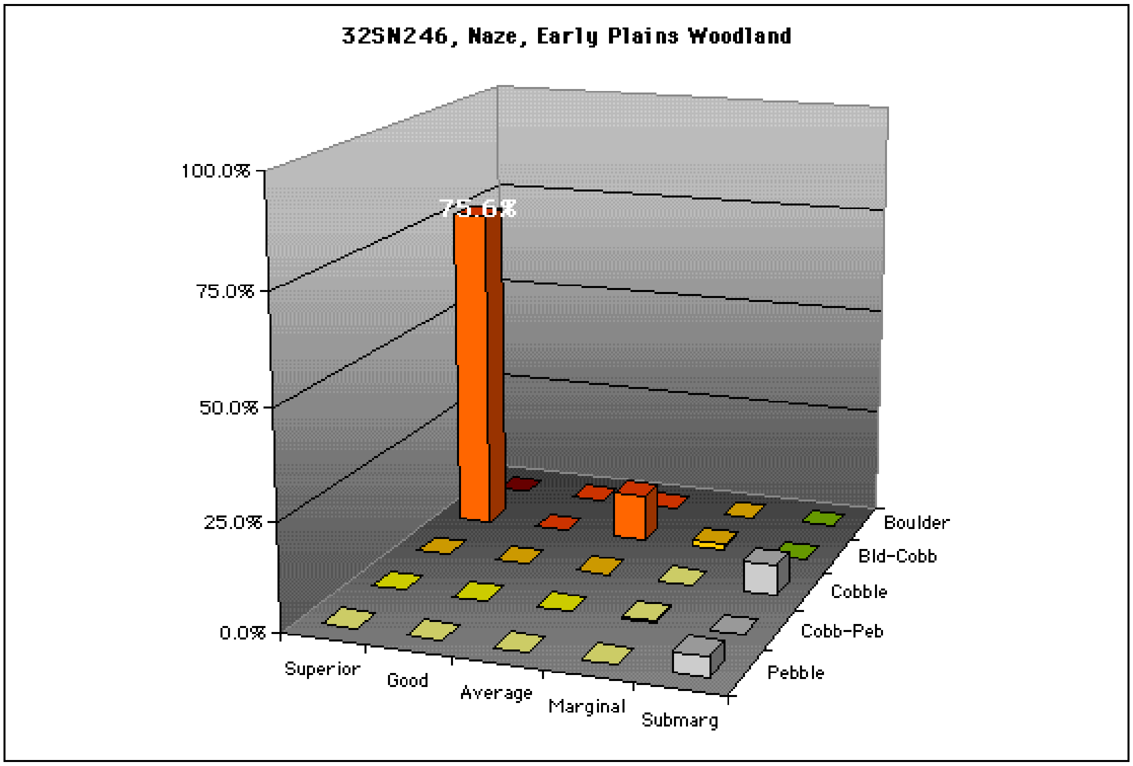
Appendix 2. 21RM225, Lucas.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			LoWR 0.5		
Boulder-Cobble	KRF 20.9		SRC 39.5	TRS 9.3	
Cobble					
Cobble-Pebble		RRC 8.6		Quartz 2.1	
Pebble					nID 19.1

Region / Sub	South Agassiz / Upper Red	**Sample Size**	580
Component	Northeastern Plains Village	**Diversity**	10
Reference	M.G. Michlovic, personal communication 2002	**Use Pattern**	S

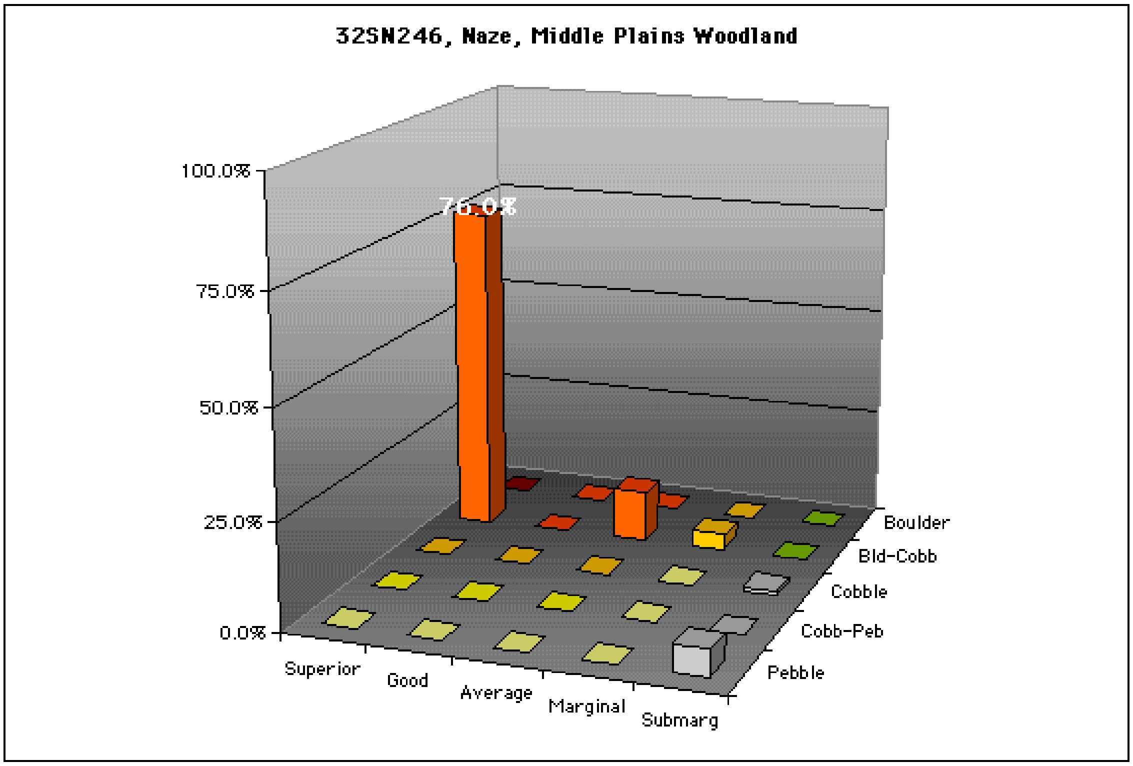
Appendix 2. 32SN246, Naze (Early Plains Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder					
Boulder-Cobble	KRF 75.6		SRC 10.9	TRS 1.4	
Cobble					Basaltic 6.9 Granitic 0.1
Cobble-Pebble				Quartz 0.4	
Pebble					nID 4.5

Region / Sub	South Agassiz / Upper Red	**Sample Size**	1,176
Component	Early Plains Woodland	**Diversity**	11
Reference	Picha and Gregg 1987	**Use Pattern**	?

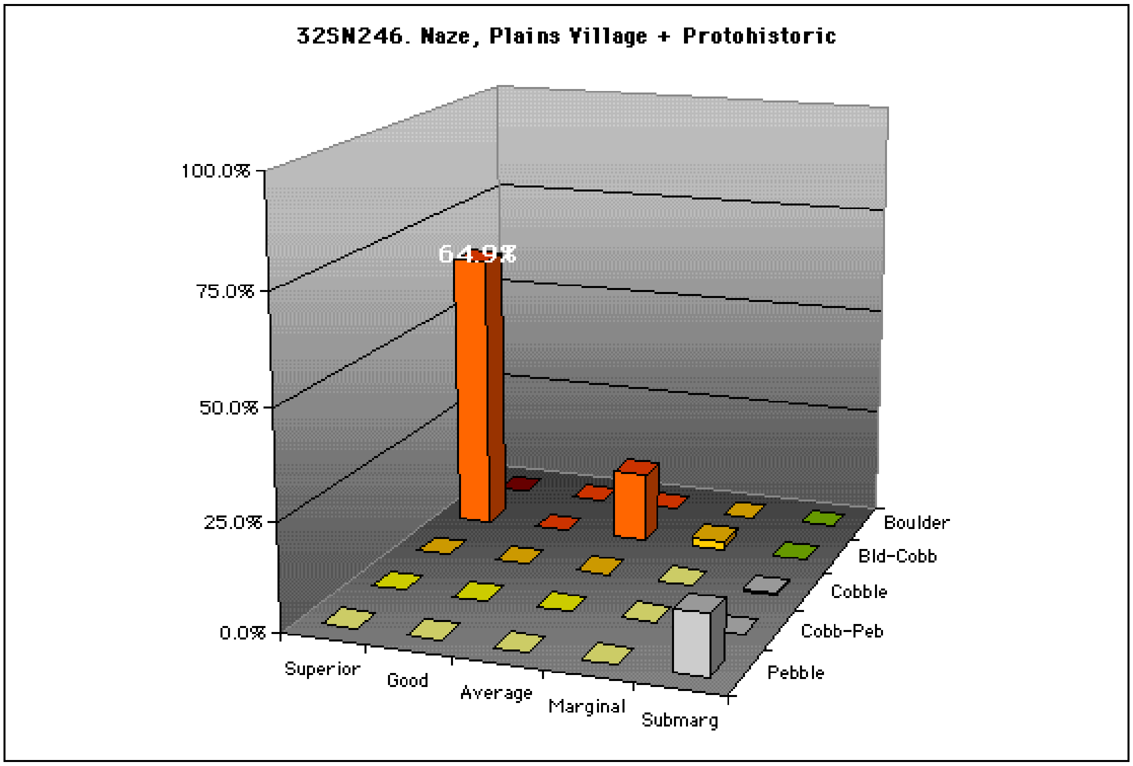
Appendix 2. 32SN246, Naze (Middle Plains Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder	Obsidian 6.1				
Boulder-Cobble	KRF 76.0		SRC 12.0	TRS 3.9	
Cobble					Basaltic 1.0 Granitic 0.1
Cobble-Pebble				Quartz 0.3	
Pebble					nID 6.3

Region / Sub	South Agassiz / Upper Red	**Sample Size**	7,979
Component	Middle Plains Woodland	**Diversity**	14
Reference	Picha and Gregg 1987	**Use Pattern**	?

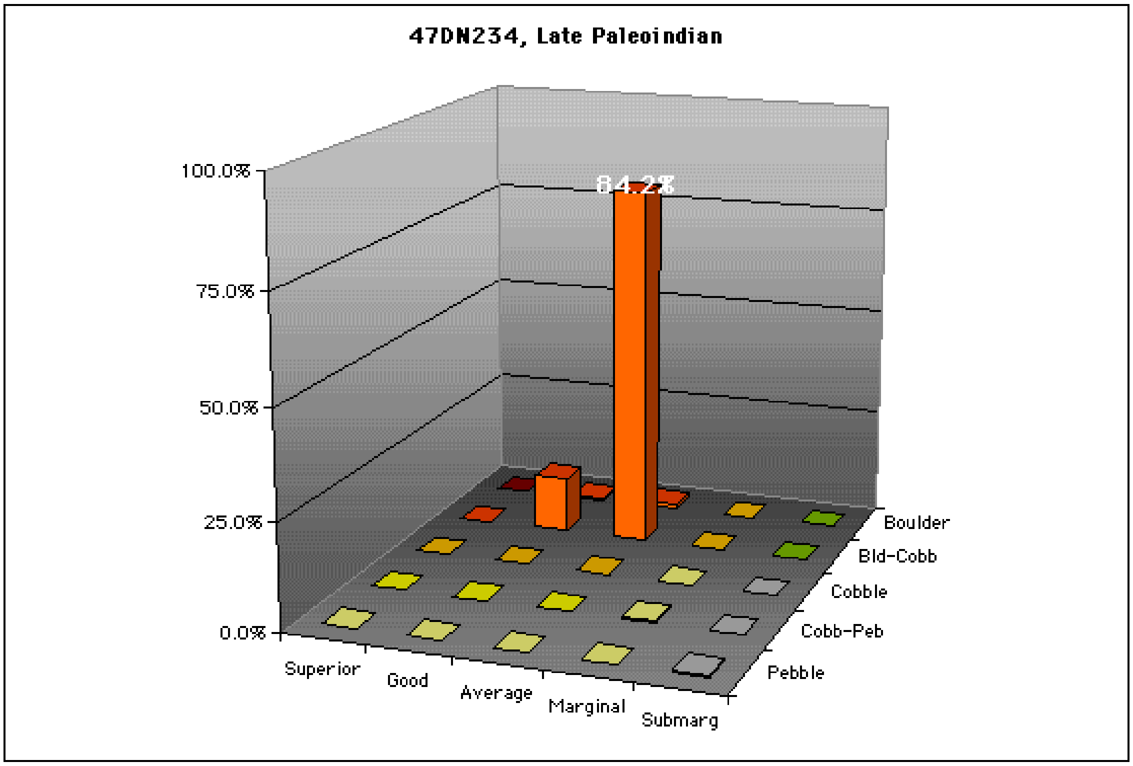
Appendix 2. 32SN246, Naze (Plains Village + Protohistoric).



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder	Obsidian < 0.1				
Boulder-Cobble	KRF 64.9		SRC 16.4	TRS 2.1	
Cobble					Basaltic 0.4 Granitic < 0.1
Cobble-Pebble				Quartz 0.3	
Pebble			WRG Group 0.1		nID 13.9

Region / Sub	South Agassiz / Upper Red	**Sample Size**	8,524
Component	Plains Village plus protohistoric	**Diversity**	15
Reference	Picha and Gregg 1987	**Use Pattern**	?

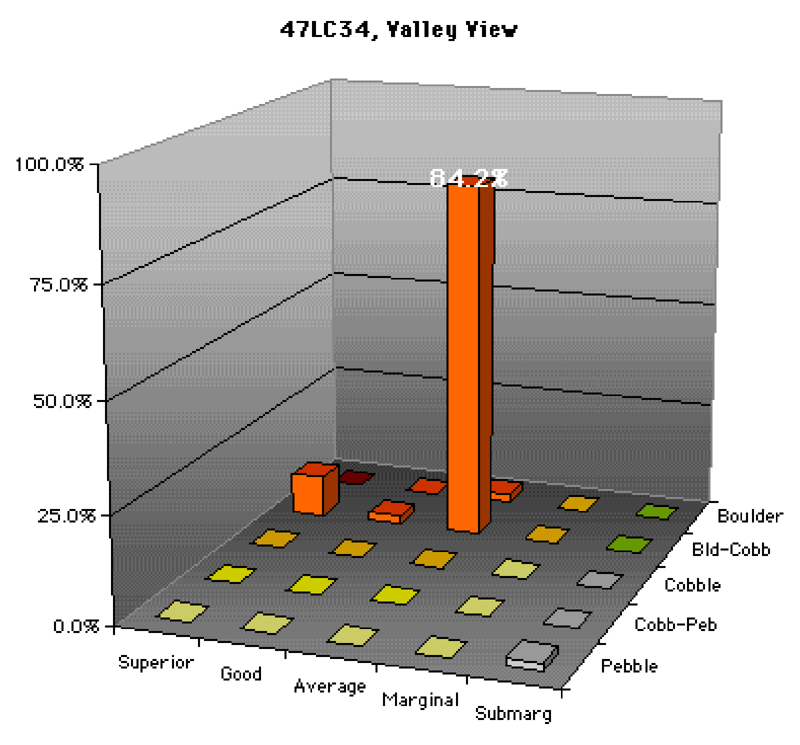
Appendix 2. 47DN234.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder		Jasper Tac 0.4	Hixton Grp 1.3		
Boulder-Cobble		CVC 13.2	PdC 84.2		
Cobble					
Cobble-Pebble				Quartz 0.4	
Pebble					nID 0.4

Region / Sub	Hollandale	**Sample Size**	228
Component	Late Paleoindian	**Diversity**	6
Reference	Wendt 2003	**Use Pattern**	B

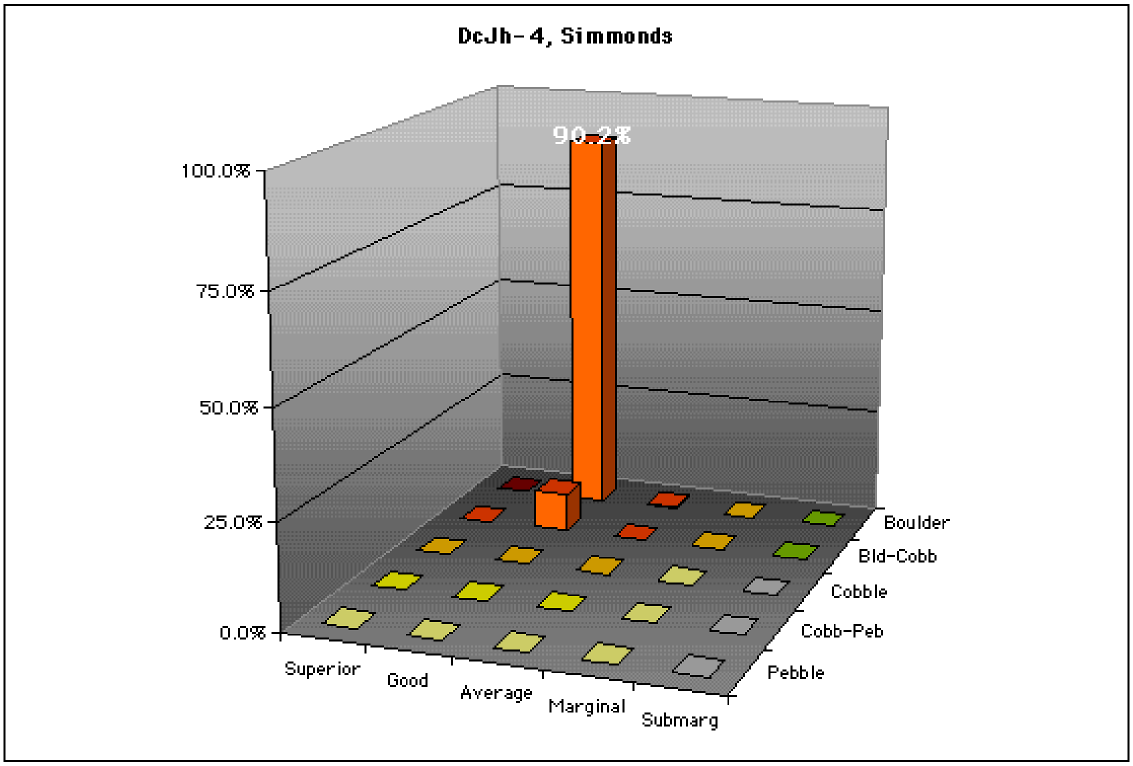
Appendix 2. 47LC34, Valley View.



%	Superior	Good	Average	Marginal	Submarginal
Boulder			Hixton Grp 1.9		
Boulder-Cobble	Burlington 9.7	Galena 2.2	PdC 84.2		
Cobble	GMC < 0.1				Basaltic < 0.1
Cobble-Pebble				Quartz < 0.1	
Pebble					nID 1.8

Region / Sub	Hollandale	**Sample Size**	4,251
Component		**Diversity**	12
Reference	Withrow 1983	**Use Pattern**	S

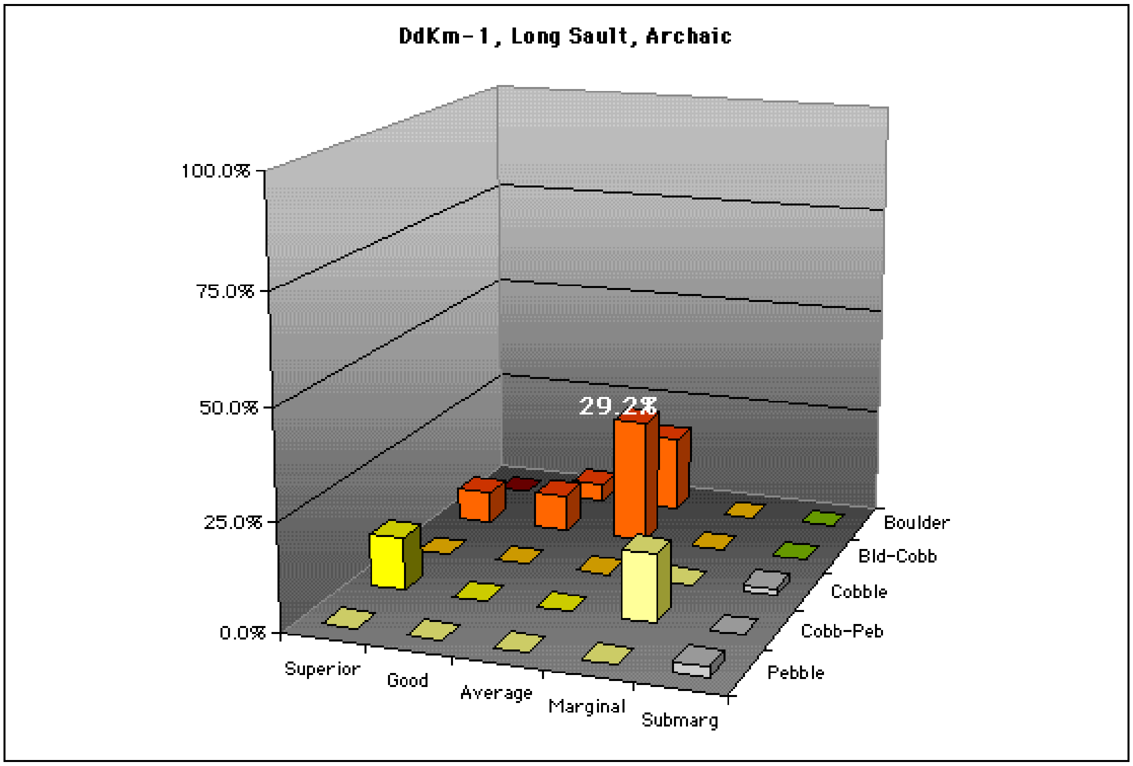
Appendix 2. DcJh-4, Simmonds.



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder		Jasper Tac 90.2	KLS 0.3		
Boulder-Cobble		Amk Grp 6.2 GFS 3.0 Kakabeka 0.1			
Cobble					
Cobble-Pebble	HBLC < 0.1			Quartz < 0.1	
Pebble					nID 0.1

Region / Sub	West Superior / Arrowhead	**Sample Size**	11,040
Component	Paleoindian	**Diversity**	8
Reference	Halverson 1992	**Use Pattern**	B

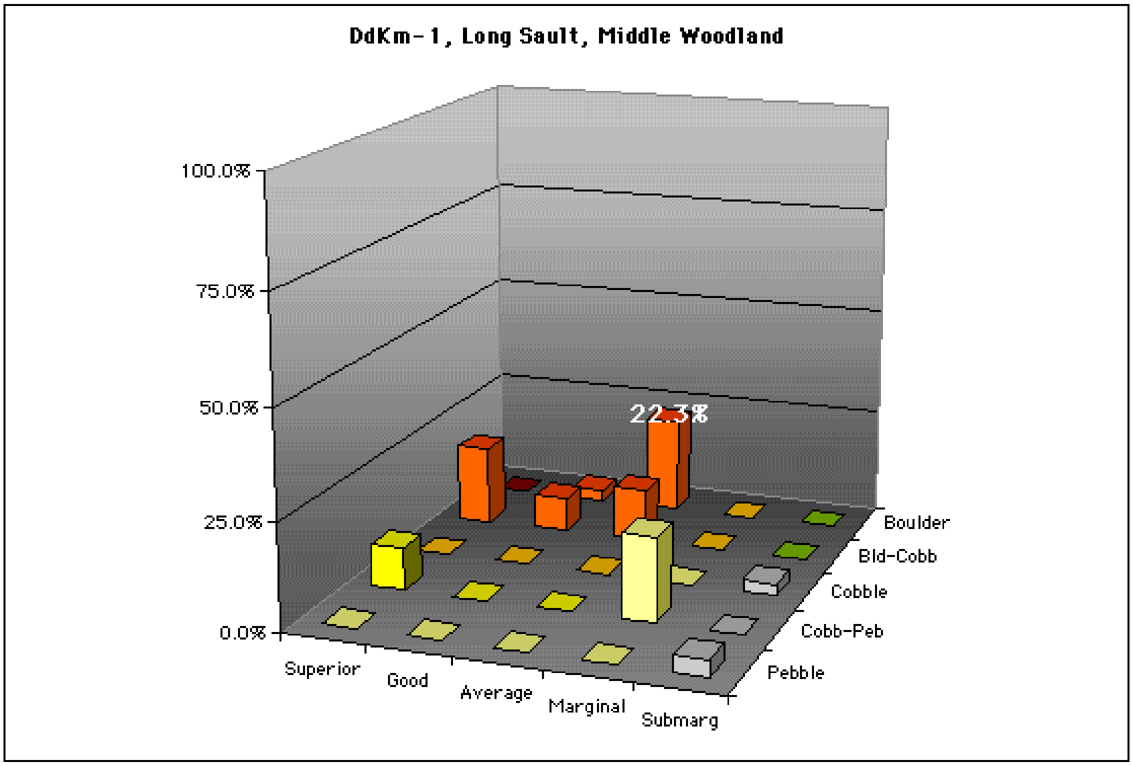
Appendix 2. DdKm-1, Long Sault (Archaic).



%	**Superior**	**Good**	**Average**	**Marginal**	**Submarginal**
Boulder		Jasper Tac 4.1	LoWR 17.3 LoWS 1.8		
Boulder-Cobble	KRF 7.5	GFS 8.9	SRC 29.2		
Cobble					Basaltic 1.6
Cobble-Pebble	HBLC 12.2			Quartz 15.9	
Pebble					nID 2.4

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	797
Component	Archaic	**Diversity**	10
Reference	Arthurs 1982, 1986	**Use Pattern**	C

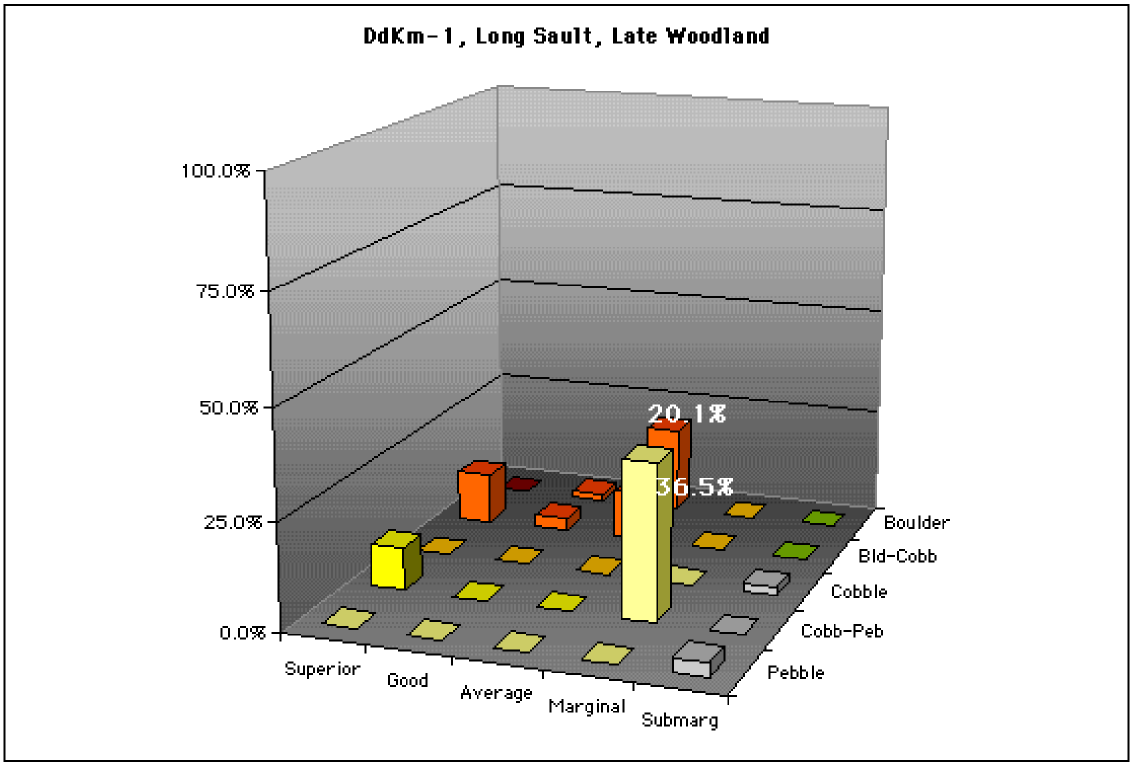
Appendix 2. DdKm-1, Long Sault (Middle Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 2.6	LoWR 21.1 LoWS 1.1		
Boulder-Cobble	KRF 18.4	GFS 8.1	SRC 12.4		
Cobble					Basaltic 2.7
Cobble-Pebble	HBLC 10.0			Quartz 19.7	
Pebble					nID 3.8

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	966
Component	Middle Woodland	**Diversity**	11
Reference	Arthurs 1982, 1986	**Use Pattern**	C?

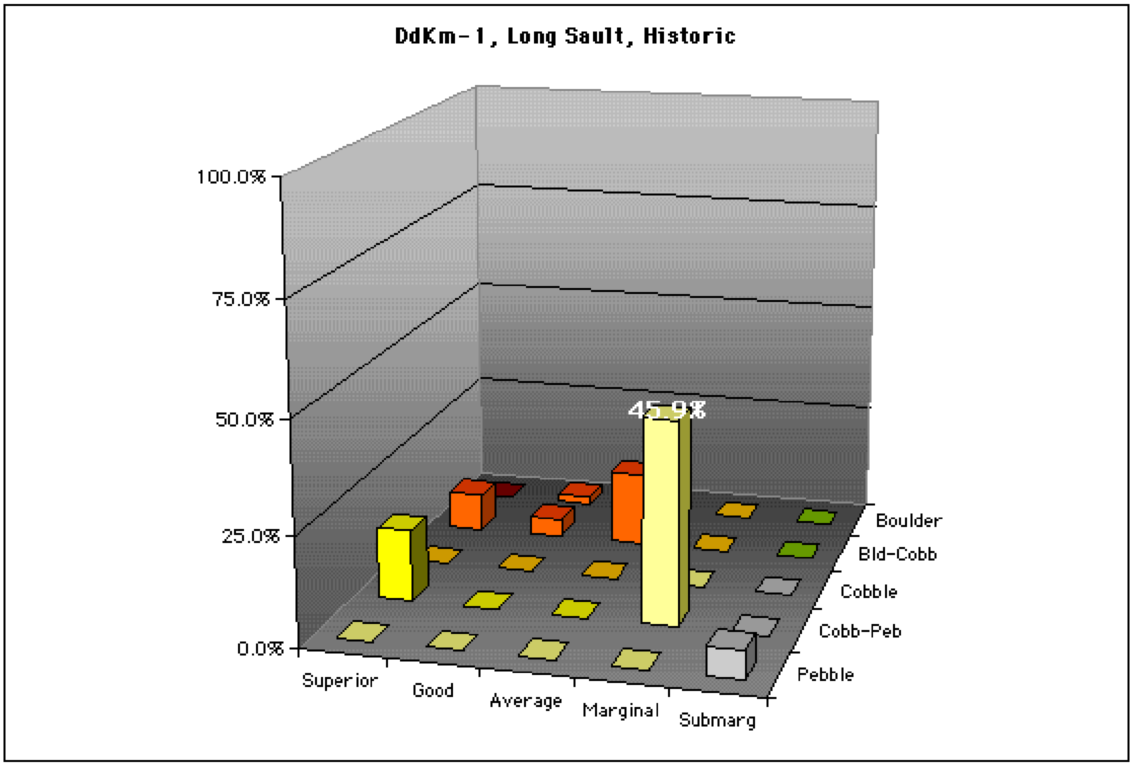
Appendix 2. DdKm-1, Long Sault (Late Woodland).



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 1.4	LoWR 19.1 LoWS 0.9		
Boulder-Cobble	KRF 11.8	GFS 3.2	SRC 11.7		
Cobble					Basaltic 1.9
Cobble-Pebble	HBLC 10.1			Quartz =36.5	
Pebble					nID 3.2

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	1,081
Component	Late Woodland	**Diversity**	12
Reference	Arthurs 1982, 1986	**Use Pattern**	P

Appendix 2. DdKm-1, Long Sault (Historic).



%	Superior	Good	Average	Marginal	Submarginal
Boulder		Jasper Tac 1.8			
Boulder-Cobble	KRF 8.6	GFS 4.1	SRC 16.8		
Cobble					
Cobble-Pebble	HBLC 16.4			Quartz 45.9	
Pebble					nID 6.4

Region / Sub	South Agassiz / Tamarack; West Superior / Arrowhead	**Sample Size**	220
Component	Historic	**Diversity**	8
Reference	Arthurs 1982, 1986	**Use Pattern**	P

Appendix 3. List of sites and assemblages constituting the data set.

Appendix 3 lists the sites and assemblages constituting the data set, along with the Smithsonian trinomial (U.S) or Borden number (Canada); site name (or field number), when available; a literature or database reference; sample size; aggregation information (column headed +); and context information (usually component).

The appendix is first subdivided by county for sites in Minnesota, or by other state or province for sites outside of Minnesota. Within each division, sites are ordered by Smithsonian trinomial for American sites, and Borden number for Canadian sites.

Because the data for this study were acquired over a long period and from many kinds of sources (including grey literature, personal communications, unpublished research), literature citations are not available for all assemblages. In most such cases, a catalog number or database reference has been provided instead. These are tied to a specific institution (see table below). These references make it possible to identify the specific data, especially when used in conjunction with information from files at the Office of the State Archaeologist and the State Historic Preservation Office. In the small number of cases, neither literature nor institutional information is available; any available, relevant information is provided instead.

Key to information on site and assemblage data aggregation.

Key	Explanation	Key	Explanation
P	Paleoindian	x	Excluded from general aggregation (specialized site, atypical assemblage, etc.)
A	Aceramic	-	Not included in general aggregation (unclear associations or mingled multicomponent)
C	Ceramic	*	Poorer quality data, not used in data aggregation.
V	Village cultures	§	Selected site or assemblage included in App. 1 maps (symbol follows site number).

Abbreviations for institutions.

Abbrev.	Institution	Abbrev.	Explanation
IMA	Institute for Minnesota Archaeology	SHPO	State Historic Preservation Office (site files)
MHS	Minnesota Historical Society (catalog number)	SMM	Science Museum of Minnesota
MSUM	Minnesota State University Moorhead	UM	University of Minnesota, Twin Cities (accession number)

NB: In site names, SP = State Park

Appendix 3. IOWA

Site No.	Site Name	Reference	n=	+	Context
13CK405	Cherokee	Anderson 1980	404	*	Middle Archaic
13CK405	Cherokee	Anderson 1980	10,144	*	Early Archaic
13CK405	Cherokee	Anderson 1980	2799	*	Paleoindian
13HA385	Allen Fan	Fishel 2003a, 2003b	415	A	Late Archaic
13HA385	Allen Fan	Fishel 2003a, 2003b	5,230	A	Early Archaic

Appendix 3. MANITOBA

Site No.	Site Name	Reference	n=	+	Context
DjLx-1	Lovstrom	Nicholson 1986	167	C	

Appendix 3. MINNESOTA, Aitkin County

Site No.	Site Name	Reference	n=	+	Context
21AK9 §	Battle Island	UM 867	648	C	
21AK11 §	Sand Lake	UM 777 F. Florin, pers. comm. 2002	880	C	
21AK35 §	Sather	MHS 1993-127	226	C	Area 1, TU 1
21AK35 §	Sather	MHS 1993-127	63	C	Area 2
21AK35 §	Sather	MHS 1993-127	155	C	Other
21AK44	Aitkin Lake II	MHS 1997-159 Emerson & Magner 1998	16	C	
21AK45	Aitkin Lake III	MHS 1997-160 Emerson & Magner 1998	28	A	
21AK58 §	Cedar Creek	MHS 1989-495 MHS 1991-5 Allan 1993	1,198	-	
21AK59	Ripple Lake	MHS 1991-406	22	C	
21AK60	--	MHS 1994-203	51	C	
21AK61 §	--	MHS 1994-204	121	A	
21AK62	--	MHS 1994-205 MHS 2002-006	15	A	
21AK80	Vander May	MHS 1993-185	10	C	
21AK88	West Twin Lake	MHS 1997-161	4	-	

Appendix 3. MINNESOTA, Anoka County

Site No.	Site Name	Reference	n=	+	Context
21AN1 §	Howard Lake	UM 309	346	C	

Appendix 3. MINNESOTA, Anoka County

Site No.	Site Name	Reference	n=	+	Context
21AN153	--	Vermeer 2002	1	-	
21AN172	--	Vermeer et al. 2008	1	-	
21AN	Eagle Brook	Harrison 2001a	2	-	

Appendix 3. MINNESOTA, Becker County

Site No.	Site Name	Reference	n=	+	Context
21BK1 §	Mitchell Dam	UM 305	285	C	
21BK5	Frazee Damsite Park	MHS 1988-379	8	*	
21BK14	Shell Lake	UM 537, UM 589	79	C	
21BK18	Skip-a-day Campsite	MHS 1993-42	7	*	
21BK32	Dunton Locks County Park	MHS 1989-496	7	*	
21BK33 §	Lake Sallie Access	MHS 1987-264 MHS 1987-45 MHS 1988-354 MHS 1990-37	115	*	
21BK35	Tamarac Landing	MHS 1990-71	10	*	
21BK36	Tamarac Trail	MHS 1990-70	7	*	
21BK41	Detroit Lakes Sewer Segment No. 5	MHS 1993-334	26	A	
21BK44	North Twin Lake	MHS 1991-316	26	P	
21BK91	Sunny Side Access	MHS 1999-473	5	C	
21BK101	West Pond	Hohman-Caine & Goltz 2002a	10	*	
21BK102	Mill Lake	Hohman-Caine & Goltz 2002a	1	*	
21BK110	Little Floyd Lake?	Bakken 2008	239	C	
21BK111 §	--	Florin 2006	331	A	
21BK-FS	CSAH5	MHS 1989-510	1	*	
21BK	BK-02-06	Hohman-Caine & Goltz 2002a	5	*	

Appendix 3. MINNESOTA, Beltrami County

Site No.	Site Name	Reference	n=	+	Context
21BL2 §	Waskish	Gonsior & Radford 2005	428	C	
21BL31 §	Lake Boulevard / Pamida	Hohman-Caine & Goltz 2002b; Bakken 2009	1,154	-	

Appendix 3. MINNESOTA, Beltrami County

Site No.	Site Name	Reference	n=	+	Context
21BL37 §	Midway	Kluth et al. 2000; Leach Lake Heritage Sites Program 2002	306	-	Undisturbed strata
21BL51	DNR Pines	MHS 1988-171	33	C	
21BL54	Movil Lake	MHS 1989-459	19	*	
21BL55	Decker	MHS 1989-470	18	*	
21BL56	MnDOT Headquarters	MHS 1991-4 MHS 1991-185	41	A	
21BL59 §	Painted	MHS 1990-282 MHS 1996-490	105	C	
21BL60	Turtle	MHS 1990-327	15	*	
21BL61	--	MHS 1991-438	3	-	
21BL62	Hiltz	MHS 1990-328 MHS 1993-273	29	C	
21BL63	Blackduck Lake	MHS 1991-436	6	-	
21BL75	Mission Lithic	Kluth & Kluth 2000a	20	A	
21BL158	Paul Bunyan	MHS 1995-362	70	A	
21BL180	Lake Bemidji Outlet	MHS 1997-155	30	C	
21BL219	Waskish Airport 1	Mulholland & Mulholland 2001	1	-	
21BL220	Morgan	Kluth & Kluth 2001a	5	-	
21BL221	Field 1	Kluth & Kluth 2001b	2	C	
21BL222	Schoolcraft Crossing	Kluth & Kluth 2001b	15	C	
21BL223	North Marquette	Kluth & Kluth 2001b; Jones 2002	42	C	
21BL228	Buried Cable	Jones & Carlson 2002	6	-	
21BL235	Lake Bemidji Shelter Building	MHS 2003-140	15	-	
21BL243	Waskish Hatchery	MHS 2003-247	2	-	
21BL	--	G. Goltz, pers. comm. 2001	10	-	
21BL	CSAH 20	MHS 1990-134	31	*	

Appendix 3. MINNESOTA, Benton County

Site No.	Site Name	Reference	n=	+	Context
21BN6 §	East Terrace	MHS 1985-40 MHS 1985-211 MHS 1991-397 BRW 1994	6,918	-	

Appendix 3. MINNESOTA, Benton County

Site No.	Site Name	Reference	n=	+	Context
21BN8 §	Little Rock Lake North	MHS 1988-297 MHS 1989-422	2,949	C	
21BN9	Little Rock Lake South	MHS 1988-298 MHS 1989-421	58	-	
21BN10	Parsons	MHS 1991-319	13	C	
21BN11	Langola Gravel Quarry	MHS 1991-322	6	-	
21BN12	Ireland	MHS 1991-415 MHS 1993-243	12	A	
21BN13	East Elk River	MHS 1993-241	37	C	
21BN14	Mayhew Creek	MHS 1993-242	45	A	
21BN25	--	Schmidt & Vermeer 2005	1	-	

Appendix 3. MINNESOTA, Big Stone County

Site No.	Site Name	Reference	n=	+	Context
21BS19	Big Stone Lake II	MHS 1995-186	22	C	
21BS29	Lannon Lake	MHS 1987-84	6	*	
21BS38	Meadowbrook Campground Terrace	MHS 1994-193	27	C	+
21BS39 §	Lindholm-Gustafson Farms	MHS 1994-192	212	x	
21BS53	Bonanza Unit Picnic Area	MHS 2004-108	4	V	
21BS54	Bonanza Unit Water Access	MHS 2004-109	2	-	

Appendix 3. MINNESOTA, Blue Earth County

Site No.	Site Name	Reference	n=	+	Context
21BE3	Judson (Jones)	UM 184	13	x	
21BE5 §	Owen D. Jones	UM 243	307	V	
21BE6	Lewis	UM 340 MHS 1987-82	6	V	
21BE21	Eagle Lake	MHS 1990-31 MHS 1991-31	103	A	
21BE66	Wussow	MHS 1988-47	17	A	
21BE67	Rose	MHS 1986-33 MHS 1991-30 MHS 1992-378	85	A	
21BE71	Loon Lake Access	MHS 1987-265	42	x	

Appendix 3. MINNESOTA, Blue Earth County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21BE72 §	Bartsch	MHS 1988-53 MHS 1988-378	1,208	x	
21BE73	Caldwell	MHS 1988-51	4	*	
21BE78	--	MHS 1989-466	70	*	
21BE80	--	MHS 1989-468	80	*	
21BE83	--	MHS 1989-471	12	*	
21BE84	--	MHS 1989-472	16	*	
21BE86	--	MHS 1989-474	6	*	
21BE88	--	MHS 1989-476	16	*	
21BE89	--	MHS 1990-459	1	-	
21BE93 §	Mills Lake	MHS 1993-304 MHS 1991-45	1,107	A	
21BE94	Kendall	MHS 1991-46	4	A	
21BE95 §	Fleming Field	MHS 1991-47 MHS 1992-388	291	x	
21BE96	Fleming Findspot	MHS 1991-48	1	-	
21BE97	Garden City	MHS 1991-49 MHS 1992-379	2	A	
21BE98	Bergeman	MHS 1991-50 MHS 1991-146	4	A	
21BE121 §	Hanel II	MHS 1991-147 MHS 1992-1121 MHS 1992-168 MHS 1993-128	441	A	
21BE122 §	Rush Lake	MHS 1991-148 MHS 1992-169 MHS 1993-294	223	A	
21BE123	Belgard	MHS 1991-149 MHS 1992-125	10	x	
21BE124	Ulrich	MHS 1991-150 MHS 1992-170	5	x	
21BE125	County Road 186	MHS 1990-262	11	*	
21BE127	Kvitek I	MHS 1990-264	16	*	
21BE128	Kvitek II	MHS 1990-265	13	*	
21BE135	Malvin	MHS 1993-277	59	C	
21BE136	Sternitzke	MHS 1993-278	57	A	

Appendix 3. MINNESOTA, Blue Earth County

Site No.	Site Name	Reference	n=	+	Context
21BE137 §	Sandon	MHS 1991-293 MHS 1992-167 MHS 1993-184 Skaar 1993	2,977	x	Surface, plowzone
21BE137	Sandon	MHS 1992-167 Skaar 1993	59	x	Sub-plowzone
21BE137	Sandon	MHS 1992-167 Skaar 1993	2	x	With vessel (deep component)
21BE141	Stauffer / Wendt	MHS 1992-135	25	x	
21BE146	Winkler Findspot	MHS 1986-34	8	-	
21BE147	--	MHS 1989-479	13	*	
21BE155	Scheuerer	MHS 1993-296	2	-	
21BE163 §	Art Maxwell	MHS 1991-199	124	A	
21BE210	Leen	MHS 1999-23	2	-	
21BE255	Friedrichs	MHS 1994-87	9	-	
21BE257	--	Forsberg et al. 1999	28	x	
21BE258	--	Forsberg et al. 1999	73	A	
21BE259 §	--	Forsberg et al. 1999	240	x	
21BE	--	MHS 1990-272		-	

Appendix 3. MINNESOTA, Brown County

Site No.	Site Name	Reference	n=	+	Context
21BW1	Synsteby	MHS 1995-360	1	-	
21BW20	Clear Lake	MHS 1988-355	7	*	
21BW81	--	MHS 1992-488	14	A	
21BW82	Helget Burials	Finney & Hagglund 1996	1	-	
21BW91	New Ulm Regional Office	MHS 2003-125	1	-	

Appendix 3. MINNESOTA, Carlton County

Site No.	Site Name	Reference	n=	+	Context
21CL24	Jaskari Plantation	MHS 1996-492	10	C	
21CL25 §	Jaskari Dam	MHS 1996-493	696	C	
21CL26 §	Perch Lake Basin	MHS 1996-494	381	C	

Appendix 3. MINNESOTA, Carlton County

Site No.	Site Name	Reference	n=	+	Context
21CL27	--	Belcher & Florin 1997	15	-	

Appendix 3. MINNESOTA, Cass County

Site No.	Site Name	Reference	n=	+	Context
21CA10	Sugar Point / Leech Lake	MHS 1987-304 MHS 1989-423	73	*	
21CA24	Sand Point	MHS 1996-492	10	C	
21CA27	Steamboat Lake	MHS 1999-476	36	x	
21CA38	South Pike Bay	LeVasseur & Yourd 2002	23,948	*	
21CA59	Dam Bay	MHS 1992-472	34	C	
21CA91	Sucker Bay Shores	MHS 1999-467	25	C	
21CA161	Sanburn Lake	MHS 1987-27	8	*	
21CA170 §	Bowen Bridge	MHS 1992-141	224	C	
21CA171 §	Leech Lake Dam Tender's Site	Johnson et al. 2004	972	C	
21CA173	Webb Lake Findspot	MHS 1994-4	1	-	
21CA184 §	Roosevelt Lake	Bakken 1995b	4,263	C	
21CA185	Washburn Lake CCC Camp / Clinton Converse	MHS 1995-317	1	-	
21CA186	Rock Lake Campground	MHS 1995-315 MHS 1996-491	10	C	
21CA188	Felknor	MHS 1996-151	55	C	
21CA198 §	East Lydick Creek	Emerson 1996	715	C	ELC C-W
21CA198 §	East Lydick Creek	Emerson 1996	873	C	ELC C-E Upper
21CA198 §	East Lydick Creek	Emerson 1996	427	C	ELC D
21CA198 §	East Lydick Creek	Emerson 1996	342	A	ELC C-E Lower
21CA198 §	East Lydick Creek	Emerson 1996	83	-	Other
21CA227	Outing Park	MHS 1991-399	3	-	
21CA281	Norway Beach Campground Site	MHS 1996-522	1	-	
21CA392	Long Lake (USFS 05-178C)	SHPO files, Forest Service Inventory Form	4	C	
21CA500	Haug	Kluth & Kluth 1997	7	C	
21CA501	Two Points Access	MHS 1997-162	2	C	

Appendix 3. MINNESOTA, Cass County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21CA576	Gull Narrows Access	MHS 1999-474	1	C	
21CA578	Spider Lake	MHS 1999-496	22	C	
21CA579	Lake Ada Access	MHS 2000-61	88	x	
21CA589	Cloud	Kluth & Kluth 2000b	1	C	
21CA590	Daugherty	Kluth & Kluth 2000b	1	-	
21CA591	South Gate	Emerson & Magner 2000	6	C	
21CA593	Smiths Landing I	MHS 2002-007	2	C	
21CA594	Smiths Landing II	MHS 2002-008	2	-	
21CA596	Smiths Landing IV	MHS 2002-010	5	C	
21CA645	Portage Lake Overlook	MHS 2003-33	3	-	
21CA650	Fox Creek Inlet I	MHS 2003-240	33	C	
21CA651	Fox Creek Inlet II	MHS 2003-241	2	-	

Appendix 3. MINNESOTA, Chippewa County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21CP29 §	Seim / Livingood	MHS 1985-48 MHS 1986-4 MHS 1987-2	1,103	*	Lower quality data
21CP29 §	Seim / Livingood	MHS 1987-81 MHS 1988-43 MHS 1988-392 MHS 1992-124 Gonsior & Yourd 1990	258	-	Higher quality data
21CP30 §	Toeslope	MHS 1985-49	12	*	Lower quality data
21CP30 §	Toeslope	MHS 1991-52 Gonsior & Yourd 1990	114	A	Higher quality data
21CP31	Watson Terrace	MHS 1989-461	15	*	
21CP32	Watson Crest	MHS 1989-462	48	*	
21CP42	Granite Falls II / Watertower	MHS 1989-498	19	*	
21CP44	Milton Nordstrom	MHS 1992-447	4	C	
21CP56	Lac qui Parle Lake Overlook	MHS 2001-417 MHS 2002-151	38	A	
21CP57	--	MHS 2002-149	3	-	

Appendix 3. MINNESOTA, Chippewa County

21CP59	Lac qui Parle Beaver Pond	MHS 2003-238	91	-	
21CP-FS	NSP Find Spot	MHS 1987-3 Gonsior & Yourd 1990	1	-	

Appendix 3. MINNESOTA, Chisago County

Site No.	Site Name	Reference	n=	+	Context
21CH5	--	MHS 1993-71	5	-	
21CH24	Sunrise Boat Access	MHS 2004-194	2	-	
21CH35	Milltown	MHS 2003-111	1	-	
21CH55	Comfort Lake Outlet	MHS 1988-356	2	*	
21CH57	Lindstrom	MHS 1988-377	18	A	
21CH59	Lendt Farm	MHS 1991-66 MHS 1991-296	81	C	
21CH69 §	--	Fleming 2002	4,592	x	
21CH85	--	SHPO files	1	-	
21CH93	Prince Cabin Road	MHS 1994-189	2	-	
21CH94	--	Justin et al. 2003	250	C	
21CHg	--	SHPO files	1	-	
21CH-FS7	--	MHS 1987-175	1	-	
21CH	--	Bailey 1997	45	C	
21CH	--	Bailey 1997	91	A	

Appendix 3. MINNESOTA, Clay County

Site No.	Site Name	Reference	n=	+	Context
21CY4 §	Johnson Park	MSUM collections	117	-	
21CY8	--	MSUM collections	1	-	
21CY37-38	Ponderosa I/II	MSUM collections	24	C	
21CY39 §	Ponderosa III	Michlovic 2005	1,292	C	
21CY40	Ponderosa IV	MSUM collections	16	A	
21CY41	Ponderosa V	MSUM collections	53	A	
21CY42	Ponderosa VI & VII	MSUM collections	35	C	
21CY43	Humphrey I	MSUM collections	10	-	
21CY44	Humphrey II	MSUM collections	7	C	
21CY45	Crowe I	MSUM collections	6	C	
21CY46	Crowe II	MSUM collections	1	-	
21CY47	Ralph Ness I	MSUM collections	5	C	

Appendix 3. MINNESOTA, Clay County

Site No.	Site Name	Reference	n=	+	Context
21CY48	Toll Bridge	MSUM collections MHS 1986-86-2 MHS 1990-135	109	*	
21CY60	Buffalo Bridge	MHS 1989-515	2	*	
21CY	--	UM (not accessioned)	4	C	
21CY	--	MHS 1992-407	1	-	

Appendix 3. MINNESOTA, Clearwater County

Site No.	Site Name	Reference	n=	+	Context
21CE1	Itasca Bison Kill	Shay 1971	2,340	*	
21CE2	Hill Point	UM 175, UM 655	2	C	
21CE5 §	Lower Rice Lake	Bakken 1994, 2006b	204	C	
21CE15	Lake Itasca (Headwaters)	MHS 1997-111	16	-	
21CE23	Chambers Creek East	MHS 2003-110	4	C	
21CE27	Bear Paw Campground	MHS 1994-101	40	C	
21CE28	Herberg	MHS IL1986-1 MHS IL1988-5	566	*	
21CE29	--	MHS 1987-173	3	C	
21CE36	Ness	MHS 1991-142	6	C	
21CE40	Cabin X	MHS 1994-103	33	C	
21CE41	Bear Paw Access	MHS 1994-102	17	C	
21CE50	Headwaters Pines	MHS 1994-194	15	-	
21CE58	--	Abel et al. 2001	1	-	
21CE59	--	Abel et al. 2001	1	-	
21CE60 §	--	Abel et al. 2001	334	A	
21CE-FS1	--	MHS 1987-174	1	-	

Appendix 3. MINNESOTA, Cook County

Site No.	Site Name	Reference	n=	+	Context
21CK30	Greenwood Point	Mulholland & Rapp 1992	83	A	
21CK221	Tweedledum's Place	Magner & Emerson 2001	5	P	
21CK340	Devil's Point	MHS 1999-449	5	-	
21CK341	Junco Creek	MHS 1999-455	9	-	

Appendix 3. MINNESOTA, Cook County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21CK	07-273	Johnson 2009	57	C	

Appendix 3. MINNESOTA, Cottonwood County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21CO39 §	Bingham Lake Access	Skaar et al. 1998	117	C	

Appendix 3. MINNESOTA, Crow Wing County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21CW1	Pine River / Warren Mounds	UM 35	11	C	
21CW5	Garrison Creek	MHS 1985-62	32	C	
21CW8	Seguchie Habitation and Mound Group	Trocki 2003a, 2003b	11	*	
21CW9 §	Scott	UM 768 Trocki 2003a, 2003b	2,319	C	
21CW15	Crow Wing SP Playground	MHS 1992-24 MHS 1994-104 MHS 1994-105	13	*	
21CW30	--	MHS 1993-72	9	C	
21CW39 §	--	Skaar et al. 1998	117	C	
21CW65	Hummingbird Mounds	MHS 1986-265 MHS 1987-268	300	*	
21CW65 §	Hummingbird Mounds	Rodell et al. 1999	320	C	
21CW71	Clearwater Lake	MHS 1987-267	4	-	
21CW86	St. Albans Bay	MHS 1992-239	4	*	
21CW97	Dr. Camp Mounds and Habitation	MHS 1993-285	2	-	
21CW100	Northenscola	MHS 1993-286	7	-	
21CW101	Borden Lake	MHS 1986-168 MHS 1986-271	373	*	
21CW107	Horseshoe / Sandbar Lake	MHS 1992-384	15	C	
21CW108	Green's Point	MHS 1992-385	42	A	
21CW133	Edward Bass	MHS 1993-281	3	C	
21CW134	Koernke	MHS 1993-282	9	-	
21CW138	Eliason Run Mounds and Habitation	Trocki 2003b	15	*	
21CW139	Pike Point Summit	Trocki 2003b	1	P	

Appendix 3. MINNESOTA, Crow Wing County

Site No.	Site Name	Reference	n=	+	Context
21CW186	Perch Lake	MHS 1994-201	1	-	
21CW189	--	MHS 1993-283	4	C	
21CW190	--	MHS 1993-284	1	-	
21CW201	Crosby Pit FS	MHS 1990-6	2	-	
21CW223	Little Menomin Lake	MHS 1998-161	3	-	
21CW229	--	Trocki 2003a, 2003b	12	*	
21CW230	--	Trocki 2003a, 2003b	2	*	
21CW231	--	Trocki 2003a, 2003b	4	*	
21CW237	--	Trocki 2003a, 2003b	3	*	
21CW238	--	Trocki 2003a, 2003b	4	*	
21CW239	--	Trocki 2003a, 2003b	2	*	
21CW241	Hay Creek Island	MHS 2002-12	8	-	
21CW242	Hay Creek Ridge	MHS 2002-13	2	-	
21CW243	Hay Lake Trail	MHS 2002-14	42	A	
21CW244	--	Trocki 2003a, 2003b	3	*	
21CW245 §	Donaldson	Trocki 2003a, 2003b	1,632	-	
21CW251 §	Rider	Trocki 2003a, 2003b	247	-	
21CW254	--	Trocki 2003a, 2003b	1	*	
21CW256	--	Trocki 2003b	6	*	
21CW257 §	--	Trocki 2003b	204	*	
21CW258	--	Trocki 2003b	1	*	
21CW275	--	Schmidt & Vermeer 2008	1	-	
21CW276	--	Schmidt & Vermeer 2008	52	A	
21CW277	--	Schmidt & Vermeer 2008	1	-	
21CW278	--	Schmidt & Vermeer 2008	3	-	
21CW279	--	Schmidt & Vermeer 2008	1	P	
21CW-ab	Perry	MHS 1991-198	4	-	

Appendix 3. MINNESOTA, Dakota County

Site No.	Site Name	Reference	n=		Context
21DK34	Williams Pipeline	MHS 1999-156	1	C	

Appendix 3. MINNESOTA, Dakota County					
Site No.	**Site Name**	**Reference**	**n=**		**Context**
21DK35	Kennealy Creek Village / Black Dog's Village	MHS 1994-109	6	A	
21DK69	Murphys Farm 1	SHPO site form	1	A	

Appendix 3. MINNESOTA, Dodge County					
Site No.	**Site Name**	**Reference**	**n=**		**Context**
21DO2	Rice Lake	MHS 1996-194	3	x	
21DO3	Danielson	MHS 1992-185	31	-	

Appendix 3. MINNESOTA, Douglas County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21DL1	Hoffman	UM 527	1	C	
21DL2 §	Lake Carlos SP Beach I	UM 526 MHS 1987-129 MHS 1992-410 MHS 1996-229 MHS 1997-110 MHS 2001-183 MHS 2001-418	3,316	-	
21DL3	L.D. Smith and J. Lanzo	UM 529	57	C	
21DL8 §	Nelson	MHS 1993-43	151	-	
21DL20	Old Oscar Island	MHS 1990-16	89	V	
21DL46	Christina Lake-Pelican Lake	MHS 1988-353 MHS 1990-447	137	*	
21DL68	Interlachen	MHS 1990-485	16	C	
21DL73 §	Olson	MHS 1988-389 MHS 1990-25	2,334	A	
21DL75	Swanson	MHS 1990-17	14	P	
21DL76	Johnsrud	MHS 1990-18 MHS 1991-9	85	V	
21DL77	Lake Guthrie	MHS 1990-19	1	C	
21DL78	Hammitt	MHS 1990-20	5	C	
21DL79	Adolf Dahlstrom	MHS 1990-21	8	C	
21DL80	Phillip M. Haugen	MHS 1990-22	10	C	
21DL81 §	Josephs	MHS 1990-24	99	A	
21DL84	L'Homme Dieu Causeway	MHS 1991-407	1	C	
21DL85	Burgen Lake	MHS 1991-409	35	*	

Appendix 3. MINNESOTA, Douglas County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21DL86	Latoka Lake	MHS 1991-158	4	-	
21DL87 §	Lake Mary Outlet	MHS 1991-11 MHS 1991-159	137	A	
21DL88	Holmes City	MHS 1991-12	3	-	
21DL89	Hvezda	MHS 1991-13	3	-	
21DL90 §	Basswood Shores	Justin & Schuster 1994 MHS 1991-14 MHS 1991-315	902	x	
21DL91	Vernon Anderson	MHS 1991-15	17	A	
21DL92 §	Ralph Olson	MHS 1991-16 MHS 1991-160	344	x	
21DL93	W.L. Peterson	MHS 1991-17 MHS 1991-161	12	-	
21DL94	Bergstrom / Hoglin	MHS 1991-18	9	-	
21DL95 §	Craig	MHS 1991-19 MHS 1991-162	305	x	
21DL96	Alvin Kiepe	MHS 1991-20	13	C	
21DL97	Cowdry Lake I	MHS 1992-142	28	C	
21DL98	Roger J. Hockert I	MHS 1990-273	16	*	
21DL99	Clifford & Viola Strom	MHS 1990-274	19	*	
21DL101	Roger J. Hockert II	MHS 1990-276	5	*	
21DL102	Patrick Thoenness	MHS 1990-277	2	*	
21DL103	Alex Haabala I	MHS 1992-190	3	-	
21DL104	Alex Haabala II	MHS 1992-191	2	C	
21DL105	Long Prairie River Access	Gonsior et al. 2004	59	-	
21DL106	Lake Moses Access	MHS 1995-322	6	-	
21DL108	Lake Carlos SP II	MHS 1987-176	1	-	
21DL122	Lake Carlos Contact Station	MHS 1997-156	59	C	
21DL126 §	Lake Carlos SP #3 Township Road	Gonsior et al. 2004	575	-	
21DL129	Lake Carlos SP #5	MHS 2003-213	38	C	

Appendix 3. MINNESOTA, Douglas County

Site No.	Site Name	Reference	n=	+	Context
21DL	--	MHS 1990-275	10	*	

Appendix 3. MINNESOTA, Faribault County

Site No.	Site Name	Reference	n=	+	Context
21FA98	Dahms	MHS 1989-481	24	A	
21FA99	Fowler	MHS 1989-482	26	A	
21FA105	Golly	MHS 1991-35	3	-	
21FA106	Ott	MHS 1991-36 MHS 1991-145	54	-	
21FA107	Perry	MHS 1991-37	23	A	
21FA108	Poverty Acres	MHS 1991-38	5	-	
21FA109	Riverside County Club	MHS 1991-39	2	-	
21FA111	Nyholm Wildlife-Darnell	MHS 1991-41	88	A	
21FA113	Huber Findspot	MHS 1993-274	6	A	
21FA114	Hill Findspot	MHS 1993-275	4	-	

Appendix 3. MINNESOTA, Fillmore County

Site No.	Site Name	Reference	n=	+	Context
21FL8	Riehl Mound	UM 285	3	*	
21FL19 §	Prohaska	MHS 1993-44 MHS 1994-113 MHS 1998-129 MHS 2000-173 MHS 2001-173 MHS 2001-357	395	A	
21FL59	Sasada	MHS 1992-192	10	A	
21FL61	--	MHS 1987-178	9	A	
21FL63 §	Levee	MHS 1988-3	431	V	
21FL64 §	Grinde	MHS 1988-4 MHS 1989-56	685	C	
21FL65 §	Kindem	MHS 1991-152 MHS 1991-21 MHS 1992-136 Gonsior et al. 1994; Myster 1996	1,537	x	

Appendix 3. MINNESOTA, Fillmore County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21FL66 §	Tieskotter / Stevens	MHS 1991-153 MHS 1991-22 MHS 1992-165 Gonsior et al. 1994; Myster 1996	1,121	x	
21FL67 §	Tessum / Lunde	MHS 1991-154 MHS 1991-23 MHS 1992-131 Gonsior et al. 1994; Myster 1996	379	P	
21FL68	Evenrud	MHS 1991-24 MHS 1991-188 MHS 1992-132 Gonsior et al. 1994; Myster 1996	35	A	
21FL69 §	Hahn	MHS 1991-25 MHS 1991-155 MHS 1992-133 Gonsior et al. 1994; Myster 1996	120	x	
21FL70 §	Simonson	MHS 1991-156 MHS 1991-26 MHS 1992-166 Gonsior et al. 1994; Myster 1996	296	x	
21FL71 §	Chally / Turbenson	MHS 1991-27 MHS 1993-183 MHS 1994-89 MHS 1995-368 Gonsior 1996; Gonsior & Myster 1994; Moffat et al. 1996	3,610	x	
21FL72 §	Schueler	MHS 1991-28 MHS 1991-187 MHS 1992-373	292	A	
21FL73	Mundfrom / Till	MHS 1991-105 MHS 1992-369 Gonsior 1996; Gonsior & Myster 1994; Moffat et al. 1996	86	x	
21FL74	Boyd	MHS 1991-157 Gonsior & Myster 1994	1	-	
21FL75	--	MHS 1993-271	4	A	

Appendix 3. MINNESOTA, Fillmore County

Site No.	Site Name	Reference	n=	+	Context
21FL89	Hostings	MHS 1986-25 MHS 1991-151	10	x	
21FL91	Thompson	MHS 1993-293 MHS 1994-92	66	C	
21FL92	Watson Creek Overlook	MHS 1994-91	32	-	
21FL97 §	Bestor / Gehling	MHS 1991-192	644	x	
21FL98	Camp Hidden Valley	MHS 1991-193	63	x	
21FL99	Kramer / Walsh	MHS 1991-197	8	A	
21FL100	Leistikow	MHS 1993-152	4	-	
21FL101	Bunne	MHS 1993-178	2	-	
21FL110	--	MHS 1991-40	6	-	
21FL112	Pfremmer	MHS 1996-159	77	C	
21FL114	Camp Creek No. 1	MHS 1995-367	55	x	
21FL116	Camp Creek No. 3	MHS 1995-369	5	-	
21FL117 §	Kiehne Coulee	MHS 1995-366	133	C	
21FL122	Mystery Cave 1 Low Water Crossing	MHS 2002-194	33	C	
21FL123	Forestville / Mystery Cave SP Amphitheater	MHS 2004-170	4	-	
21FL	--	MHS 1990-136	4	-	

Appendix 3. MINNESOTA, Freeborn County

Site No.	Site Name	Reference	n=	+	Context
21FE1	Albert Lea Lake	UM 542	1	P	
21FE8	Freeborn Lake	MHS 1993-45 MHS 1993-46	53	C	
21FE13	Westland	UM 722 MHS 1993-47	45	A	
21FE14	Throlson	UM 720	5	-	
21FE27	Myre-Big Island Group Camp	MHS 1987-177	2	C	
21FE30	Myre-Big Island Campground	MHS 1994-111	1	-	
21FE37 §	--	MHS 2001-174 MHS 2001-414 MHS 2002-195	459	A	
21FE40	--	MHS 2001-415	1	-	

Appendix 3. MINNESOTA, Freeborn County

Site No.	Site Name	Reference	n=	+	Context
21FE61	--	Forsberg et al. 1999	21	C	
21FE64	Myre-Big Island Trail	MHS 2001-416	3	-	
21FE65	Lower White Fox Campground	MHS 2002-224	2	-	
21FE	--	UM 162	1	-	
21FE	--	MHS 1993-48	2	C	
21FE	--	MHS 1993-49	2	-	

Appendix 3. MINNESOTA, Goodhue County

Site No.	Site Name	Reference	n=	+	Context
21GD1	Nauer Mound Group	MHS 1987-271 MHS 1990-457	222	*	
21GD3 §	Silvernale	MHS 1987-272 MHS 1988-30	256	*	
21GD3	Silvernale	Schirmer 2004	3,351	V	
21GD142	Eide Rohuer	MHS 1991-401	50	x	
21GD150	South Ridge Site	MHS 1994-178	22	C	
21GD152	Havana Ridge	MHS 1994-180	26	C	
21GD153	Rice Pond	MHS 1994-181	13	-	
21GD170	Finucan	MHS 1987-276	149	*	
21GD181	Pickerel Slough	MHS 1987-275	136	*	
21GD182	Cannon River Drive	MHS 1987-274 MHS 1993-240	59	*	
21GD208	CSAH 18 Findspot	MHS 1989-491	1	-	

Appendix 3. MINNESOTA, Grant County

Site No.	Site Name	Reference	n=	+	Context
21GR23	CSAH 11	MHS 1990-461	4	A	
21GR43	Towner Food Plot	MHS 2003-244	2	A	

Appendix 3. MINNESOTA, Hennepin County

Site No.	Site Name	Reference	n=	+	Context
21HE7	Lincoln	Bakken et al. 2006	99	C	
21HE64	Malmsten / Koehler Mounds	UM 275	3	C	
21HE76	Rice Lake	MHS 1990-30	5	C	
21HE92	Eck	UM 310	2	C	

Appendix 3. MINNESOTA, Hennepin County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21HE99	Ft Snelling	MHS 1991-419 MHS 1992-231 MHS 1996-216 MHS 1996-438	44	C	
21HE120	Eden Prairie FS I	MHS 1988-374	5	-	
21HE121	Crow River I	MHS 1988-150	18	*	
21HE122	Crow River II	MHS 1988-151 Vermeer et al. 2008	18	-	
21HE123	Crow River III	MHS 1988-152	9	-	
21HE124	Crow River IV	MHS 1988-153 Vermeer et al. 2008	13	-	
21HE125	Crow River V	MHS 1988-154 Vermeer et al. 2008	27	A	
21HE128	Rice Lake Rest Area I	MHS 1990-26	3	C	
21HE129	Rice Lake Rest Area II	MHS 1990-27 MHS 1993-151	44	C	
21HE130	Rice Lake Rest Area III	MHS 1990-28	5	-	
21HE131	Summerfields	MHS 1990-29	2	-	
21HE143	Shingle Creek	MHS 1991-321	57	*	
21HE144	Site 1	MHS 1997-75	2	-	
21HE145	Site 2	MHS 1997-76	2	-	
21HE146	Site 3	MHS 1997-77	3	-	
21HE148	Site 5	MHS 1997-78	4	A	
21HE151	Palmer Lake Park	MHS 1990-395	18	*	
21HE155	Lake Classen	MHS 1993-299	2	-	
21HE157	Lake Irene	MHS 1994-286	5	-	
21HE158	Classen Island	MHS 1994-287	79	C	
21HE159	Classen Orchard	MHS 1994-288	3	-	
21HE162	Katrina Island	MHS 1994-290	9	-	
21HE163	Repke	MHS 1994-291	1	-	
21HE165	Upper Johnson	MHS 1994-293	3	A	
21HE166	Lower Johnson	MHS 1994-294	1	-	
21HE168	Whitney	MHS 1994-295	9	C	
21HE171	Burkelt	MHS 1994-297	3	-	
21HE172	Evans	MHS 1994-298	1	-	

Appendix 3. MINNESOTA, Hennepin County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21HE175	Hilltop Farms Upland	MHS 1994-301	2	-	
21HE176	Pioneer Creek Overlook	MHS 1994-302	1	-	
21HE178	Town Line Road	MHS 1994-304	2	-	
21HE180	Pearle	MHS 1994-306	5	-	
21HE182	Dayton	MHS 1994-208	10	C	
21HE191	Lake Rebecca Entrance	MHS 1989-517	3	*	
21HE194	--	Vermeer et al. 2008	5	-	
21HE210 §	--	Nienow 2003, 2004	111	C	
21HE211	Halsted Bay Peninsula	Nienow 2003, 2004	36	C	21HE211-E
21HE211	Halsted Bay Peninsula	Nienow 2003, 2004	46	-	21HE211-F
21HE211 §	Halsted Bay Peninsula	Nienow 2003, 2004	287	C	21HE211-G
21HE211 §	Halsted Bay Peninsula	Nienow 2003, 2004	56	C	21HE211-H
21HE211	Halsted Bay Peninsula	Nienow 2003, 2004	17	C	21HE211-I
21HE311	--	Mather 2000	1	-	
21HE312 §	Mikes Island	Harrison 2000	359	A	
21HE313 §	Raspberry Island	Harrison 2000	721	-	
21HE314 §	Maple Island West	Harrison 2000	124	-	
21HE315	Maple Island East	Harrison 2000	35	-	
21HE342	Birch Pond I	Harrison 2002b	3	C	
21HE343	Birch Pond II	Harrison 2002b	1	-	
21HE374	--	Vermeer et al. 2008	50	A	
21HE375	--	Vermeer et al. 2008	2	-	
21HE376	--	Vermeer et al. 2008	1	-	
21HE377	--	Vermeer et al. 2008	4	-	
21HE378	--	Vermeer et al. 2008	2	-	
21HE379	--	Vermeer et al. 2008	5	-	
21HE §	Doerr	Florin & Madigan 1998	189	-	
21HE §	Pathfinder Village, Rice Lake	MHS 1993-67	102	C	

Appendix 3. MINNESOTA, Hennepin County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21HE	--	MHS 1991-389	5	*	
21HE	--	MHS 1991-390	2	*	
21HE	--	MHS 1991-392	2	*	
21HE	--	MHS 1991-393	2	*	

Appendix 3. MINNESOTA, Houston County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21HU1	Hogback	UM 280, UM 368	30	V	
21HU2	Farley Village	UM 248 MHS 1988-210	40	*	
21HU4	Wilsey	UM 247, UM 279	14	V	
21HU22	Reno Cave	UM (not accessioned)	4	C	
21HU26	Yucatan Village	MHS 1991-432	9	-	
21HU39	Riceford Creek	MHS 1991-433	1	-	
21HU51 §	Cherry I	MHS 1997-248	167	C	
21HU64	Botcher II	MHS 1989-483	6	-	
21HU146	Mound Prairie East	MHS 1989-463	59	*	
21HU148	Hahn	MHS 1988-203	54	*	
21HU149	Lind	MHS 1988-372	7	A	
21HU150	Jensen	MHS 1991-434	8	A	
21HU159	Conniff II	MHS 1993-179	17	x	
21HU166	Vix	MHS 1997-203	41	x	
21HU167 §	Belongie	MHS 1997-204	467	C	
21HU168	Skree I	Skaar et al. 1998	1	C	
21HU169	Cushings Peak	Skaar et al. 1998	4	-	
21HU170	Skree II	Skaar et al. 1998	1	C	
21HU	Bridge 8160 Findspot	MHS 1992-382	7	A	
21HU	Bridge 8159 Findspot	MHS 1992-381	3	-	

Appendix 3. MINNESOTA, Hubbard County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21HB12 §	Bosell	MHS 1990-453	181	C	
21HB19	Palmer Pines	MHS 1990-72 Thompson 1994	23	C	
21HB21	Lake Hattie Access	MHS 1987-305	25	C	
21HB22	Thomas-Mecham	MHS 1989-344	32	*	

Appendix 3. MINNESOTA, Hubbard County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21HB23	Allen I	MHS 1990-454	45	C	
21HB24	Allen II	MHS 1990-455	4	A	
21HB25	Middle Crooked Lake	MHS 1992-143 MHS 1996-167	17	C	
21HB26	LaSalle Creek	MHS 1993-265	6	*	
21HB26	LaSalle Creek	Kluth & Kluth 1994	46	C	
21HB27	Stromback	MHS 1991-396	39	A	
21HB28	Little Midge Lake	MHS 1993-303	3	-	
21HB48	Douglas Lodge Cabin 7	MHS 1998-349	4	-	
21HB49	--	Lindbeck & Perkl 1999	11	-	
21HB50	--	Lindbeck & Perkl 1999	5	-	
21HB51	Mantrap Beach	MHS 2000-116	1	C	
21HB55	Beauty Lake Southwest	Caine & Goltz 2002	1,737	P	
21HB56	Island Creek / Mud Lake	Caine & Goltz 2001	3	C	

Appendix 3. MINNESOTA, Isanti County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21IA19	--	MHS 1989-518	1	C	
21IA43	West Point	MHS 1986-288	12	C	
21IA44	--	MHS 1988-169	8	*	
21IA58	Long Lake	Mather 2006	12	-	
21IA59	Overby	Mather 2006	2	C	
21IA60	Royal Oaks	MHS 1995-326	82	C	

Appendix 3. MINNESOTA, Itasca County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21IC31 §	Patrow	UM 778, UM 798	649	-	
21IC65	--	MHS 2003-235	38	A	
21IC77	--	MHS 2003-236	8	C	
21IC103	Thistledew Campground	MHS 1987-179 MHS 2000-112	15	C	
21IC116	Lost Lake I	MHS 1995-121	98	A	
21IC117	Lost Lake II	MHS 1995-122	48	A	

Appendix 3. MINNESOTA, Itasca County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21IC302	Zaiser Island	MHS 1999-163	4	-	
21IC315	Round Lake	MHS 1999-495	8	A	Upper component
21IC315	Round Lake	MHS 1999-495	5	A	Lower component
21IC316	Deer Lake Overlook	MHS 1999-447	2	-	
21IC317	Deer Lake Beach	MHS 1999-448	62	C	
21IC318	South Sturgeon Homesite	MHS 1999-471	3	-	
21IC319	Point Bay East	MHS 1999-463	39	-	
21IC325	Nelson	Kluth & Kluth 2001a	8	C	
21IC331	Holm	MHS 2002-135	4	-	
21IC336	Buttonbox Campground	MHS 2003-234	1	-	
21IC	--	MHS 1990-139	5	*	

Appendix 3. MINNESOTA, Jackson County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Component**
21JK1	Johnson	UM 427	26	C	
21JK3	Hurley	MHS 1990-450	5	*	
21JK6-16	Robertson Park	MHS 1995-12 MHS 1996-161	41	C	
21JK8	Gerdes	MHS 1991-404	3	*	
21JK12	Duck Lake I	Schoen 2002	160	*	
21JK19	Independence Lake	MHS 1990-396	21	*	
21JK23	Block	MHS 1993-126	2	-	
21JK30	Kilen Woods SP Campground	MHS 2003-171	7	-	
21JK31	Rush Lake Northwest	MHS 2003-242	4	-	

Appendix 3. MINNESOTA, Kanabec County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21KA31	Timber Ridge	MHS 1993-62	3	-	
21KA59	Rice Creek	MHS 1988-370	65	C	
21KA60	Kelling	MHS 1989-494	3	-	

Appendix 3. MINNESOTA, Kandiyohi County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21KH62	--	MHS 1989-519	4	*	

Appendix 3. MINNESOTA, Kandiyohi County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21KH83	Lindahl	MHS 1987-277	5	-	
21KH97	Sellgren	MHS 1987-278	264	*	
21KH98	Crook Lake	MHS 1989-499	107	*	
21KH99	Swan Lake Inlet	MHS 1988-351	5	*	
21KH100	Lake Lillian	MHS 1992-383	4	C	
21KH115	Sibley SP Lakeview Campground	MHS 1997-137	8	-	
21KH127	Dahl	MHS 1999-480	3	-	
21KH-FS6	Findspot 6	MHS 1989-484	1	-	

Appendix 3. MINNESOTA, Kittson County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21KT1	Lake Bronson	MHS 478, UM 148, UM 779-4-4	130	C	
21KT1	Lake Bronson	Anfinson et al. 1978	3,531	*	
21KT24	Cyrus Hanson	Breakey et al. 1994	2	-	
21KT34	--	Belcher & Florin 1997	96	C	
21KT37	Lake Bronson McCauleyville Beach Ridge	MHS 1996-290 MHS 2000-127	43	A	
21KT42	Lake Bronson SP 1	MHS 1997-283	2	A	
21KT43	Lake Bronson SP 2	MHS 1997-284	1	-	
21KT44	Lake Bronson SP 3	MHS 1997-285	1	-	
21KT45	Lake Bronson SP 4	MHS 1997-180	19	A	
21KT46	Lake Bronson SP 5	MHS 1997-287	1	-	Upper component
21KT46	Lake Bronson SP 5	MHS 1997-287	7	A	Lower component
21KT49	Lake Bronson Southwest	MHS 1999-157	10	-	
21KT50	Lake Bronson Picnic Shelter	MHS 2000-123	1	-	
21KT51	Twin Lakes Overlook	MHS 2002-16	1	-	

Appendix 3. MINNESOTA, Kittson County

Site No.	Site Name	Reference	n=	+	Context
21KT52	Bronson Dam Pre-Contact	MHS 2000-206	19	A	

Appendix 3. MINNESOTA, Koochiching County

Site No.	Site Name	Reference	n=	+	Context
21KC2 §	McKinstry	Thomas & Mather 1996	1,705	C	Late Terminal Woodland
21KC2 §	McKinstry	Thomas & Mather 1996	799	C	Middle Terminal Woodland
21KC2 §	McKinstry	Thomas & Mather 1996	178	C	Early Terminal Woodland
21KC2 §	McKinstry	Thomas & Mather 1996	233	C	Initial Woodland
21KC2 §	McKinstry	MHS 1986-264 Thomas & Mather 1996	1,129	C	General provenience
21KC3	Smith	MHS 469	47		
21KC9 §	Big Falls	MHS 1988-371 MHS 1991-1	2,737	A	
21KC9	Big Falls	MHS 1988-371	9	C	Redeposited
21KC27	James Plummer	MHS 1986-256 MHS 1988-197 MHS 1988-45	10	P	
21KC28 §	Long Sault Rapids	MHS 1985-63 MHS 1994-114 MHS 1995-319 MHS 1996-496 MHS 1998-388 MHS 1998-390	548	C	
21KC34	Agassiz Beach	MHS 1990-2	2	-	
21KC41	Hurt Lip	MHS 1992-375	1	-	
21KC57 §	Jevne Campground	MHS 1989 MHS 1995-318 MHS 1998	126	A	
21KC58	Ben Linn Landing	MHS 1996-150 MHS 1996-495	72	-	
21KC75	Hafdahl	MHS 1992-376	2	-	
21KC84	Eagle's Nest Point	MHS 1999-450	16	-	
21KC91	Gustafson	Mulholland et al. 2002a	1	-	

Appendix 3. MINNESOTA, Koochiching County

Site No.	Site Name	Reference	n=	+	Context
21KC92	Nett Lake Drive Lot 8	Myster 2002	1	-	

Appendix 3. MINNESOTA, Lac Qui Parle County

Site No.	Site Name	Reference	n=	+	Context
21LP	--	UM 743	12	-	Multi-site survey

Appendix 3. MINNESOTA, Lake County

Site No.	Site Name	Reference	n=	+	Context
21LA1 §	Pipestone Bay	Birk & Hagglund 1996	404	C	
21LA9	--	MHS 1992-420 MHS 1992-421 MHS 1994-116	7	-	
21LA19	Finland	MHS 1990-1	3	-	
21LA20	Stewart River	MHS 1990-3	4	-	
21LA21	Superior Beach	MHS 1990-40	2	-	
21LA23	Shagawa River	MHS 1992-122	24	A	
21LA41 §	Baptism River Terrace	MHS 1996-305	290	A	
21LA519	Tettegouche Lake Overlook	MHS 1999-128	1	-	
21LA524	Hitchi Gami Trail 1	MHS 2000-108	11	-	
21LA525	Mitawan Lake Access #2	Skaar 2001	2	-	
21LA	Newton-Pipestone Portage S, FS-05-241	Birk & Hagglund 1996	45	-	
21LA §	FS-09-09-05-373	Johnson 2005	1,238	C	Laurel
21LA §	FS-09-09-05-373	Johnson 2005	653	A	Aceramic
21LA	Rebecca Spears, FS-02-573	Woodward 2001	64	A	

Appendix 3. MINNESOTA, Lake of the Woods County

Site No.	Site Name	Reference	n=	+	Context
21LW11	Silver Creek	SHPO site form	2	*	
21LW15	Brush Island Tool	Kluth 1997	2	-	

Appendix 3. MINNESOTA, Lake of the Woods County

Site No.	Site Name	Reference	n=	+	Context
21LW-o	Ravndalen	SHPO site file notes, Bakken notes	4	P	

Appendix 3. MINNESOTA, LeSueur County

Site No.	Site Name	Reference	n=		Context
21LE43	Minnesota Valley Rest Area	MHS 1988-52 MHS 1988-375 MHS 1991-34	93	*	
21LE45	Chert Kiln Site	MHS 1993-70	6	-	
21LE48	Burned Tree / High Y	MHS 1989-526	3	*	
21LE48	Burned Tree / High Y	MHS 1991-435	2	-	
21LE50	Lake Dora Access	MHS 1989-523	15	*	
21LE51	Leen	MHS 1990-462	2	-	
21LE52	--	MHS 1990-463	3	-	
21LE56	Shanaska Creek	MHS 1993-301	7	-	
21LE57	Sanitation	MHS 1993-298	1	-	
21LE58	--	MHS 1990-465	1	-	
21LE67	Roots Bay Access	MHS 1996-318	1	-	
21LE70	--	Forsberg et al. 1999	47	x	
21LE79 §	Sakatah Lake Overlook	MHS 2000-182 MHS 2001-184	536	C	
21LE	--	MHS 1990-464	6	A	
21LE	--	MHS 1990-397	6	*	

Appendix 3. MINNESOTA, Lincoln County

Site No.	Site Name	Reference	n=	+	Context
21LN7?	Anderson	UM 394	67	V	
21LN41	Hendricks Park	MHS 1999-103	5	C	
21LN42	Stray Lake Access I	MHS 1999-479	2	-	
21LN43	Stray Lake Access II	MHS 1999-478	3	-	
21LN44	Stray Lake Access III	MHS 1999-477	3	-	
21LN45	Lake Benton AMA	MHS 1999-475	1	-	
21LN47	Herschberger Slough Access	MHS 2002-017	5	-	
21LN54 §	--	Palmer & Justin 2006	188	A	
21LN	DME-1	Terrell & Vermeer 2009	23	-	

Appendix 3. MINNESOTA, Lincoln County

Site No.	Site Name	Reference	n=	+	Context
21LN	DME-2	Terrell & Vermeer 2009	23	-	

Appendix 3. MINNESOTA, Lyon County

Site No.	Site Name	Reference	n=	+	Context
21LY39 §	Blanche De Reu	MHS 1991-57 MHS 1993-180	117	A	
21LY40	Van den Driesche	MHS 1991-58	5	-	
21LY41	Halbur Findspot	MHS 1991-59	1	-	
21LY42	Towne	MHS 1991-60	3	-	
21LY43 §	Rich Krueger I	MHS 1991-61	103	A	
21LY44	Krueger / Johnson	MHS 1991-62 MHS 1992-389 MHS 1993-182	36	A	
21LY48	Camden Rural Waterline I	MHS 1994-118	5	-	
21LY49	Camden Rural Waterline II	MHS 1994-117	2	-	
21LY51	Clear Lake	MHS 1995-10	8	-	
21LY52	Ribordy	MHS 1991-201	2	-	
21LY53	R&G Construction	MHS 1991-200	31	A	
21LY118	Old Camden	MHS 1999-500	38	A	
21LY120 §	Camden SP North Picnic Area	MHS 2001-208 MHS 2002-127	98	C	

Appendix 3. MINNESOTA, Mahnomen County

Site No.	Site Name	Reference	n=	+	Context
21MH5 §	North Twin Lake	Michlovic & Sather 2002	633	C	
21MH8	Sawmill Lake	MHS 1990-452	4	-	

Appendix 3. MINNESOTA, Marshall County

Site No.	Site Name	Reference	n=	+	Context
21MA1 §	Snake River	UM 149	265	C	
21MA6	Haarstad	UM 514	15	C	
21MA8	Skurdahl	UM 478, UM 482	29	C	
21MA26	WA Hanson	MHS 1989-500	6	-	
21MA28 §	Midway	Murray et al. 1991	1,826	-	Block 1

Appendix 3. MINNESOTA, Marshall County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21MA28 §	Midway	Murray et al. 1991	1,642	A	Block 2
21MA28 §	Midway	Murray et al. 1991	3,719	A	Block 3
21MA28 §	Midway	Murray et al. 1991	583	A	Block 4
21MA32 §	State School	UM 145 MHS 1992-187 MHS 1998-13	405	-	
21MA33	Donarski	MHS 1992-188	65	C	
21MA34	Middle River Crossing	MHS 1992-189	3	-	
21MA35	Johnson	MHS 1993-279	6	-	
21MA36	Hapka	MHS 1993-280	21	A	
21MA38	--	Breakey et al. 1994	14	*	
21MA39	--	Breakey et al. 1994	30	*	
21MA41	--	Breakey et al. 1994	34	*	
21MA43	--	MHS 1987-181	3	-	
21MA59 §	Middle River Gravel Lease I	MHS 1998-14	292	-	
21MA60	Middle River Gravel Lease II	MHS 1998-15	50	A	
21MA61	Middle River Gravel Lease III	MHS 1998-16	51	-	
21MA62 §	Middle River Gravel Lease IV	Peterson 1998	132	-	Surface
21MA62 §	Middle River Gravel Lease IV	Peterson 1998	101	-	Plowzone
21MA62 §	Middle River Gravel Lease IV	Peterson 1998	140	A	20-30 cm
21MA62	Middle River Gravel Lease IV	Peterson 1998	64	A	30-35 cm
21MA62 §	Middle River Gravel Lease IV	Peterson 1998	131	A	35-50 cm
21MA63	Middle River Gravel Lease V	Peterson 1998	30	x	Surface and plowzone
21MA63 §	Middle River Gravel Lease V	Peterson 1998	123	x	30-50 cm
21MA63 §	Middle River Gravel Lease V	Peterson 1998	9	-	50-55 cm
21MA63	Middle River Gravel Lease V	Peterson 1998	51	A	55-75 cm

Appendix 3. MINNESOTA, Marshall County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21MA64	Middle River Gravel Lease VI	MHS 1998-19	27	A	
21MA71	Old Mill Picnic Area	MHS 2004-107	2	-	
21MA §	91MN1	Breakey & Murray 1991a	152	-	

Appendix 3. MINNESOTA, Martin County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21MR13	Lake Okamanpeedan	MHS 1989-464	64	*	
21MR23	Sisseton Lake	MHS 1987-46	6	C	
21MR26	--	MHS 1992-240	3	-	
21MR29	Temperance Island / Lake	MHS 1989-502	2	-	

Appendix 3. MINNESOTA, McLeod County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21MC4	Echo Lake	MHS 1987-307	17	*	
21MC5	--	MHS 1990-261	4	*	
21MC6	--	MHS 1990-260	13	*	
21MC9	--	Mulholland et al. 1997	2	-	
21MC10	--	MHS 1996-219 Maki & Sluss 1997	5	C	

Appendix 3. MINNESOTA, Meeker County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21ME1	Lake Koronis East	MHS 1991-141	6	C	
21ME6	Lake Koronis Inlet	MHS 1988-48	1	-	
21ME8	Pigeon Lake	MHS 1988-387 MHS 1990-36	10	-	
21ME11	Starcevic	MHS 1991-143	1	C	
21ME12	Scheifelbein	MHS 1991-144	8	C	
21ME13	Little Spring Creek	MHS 1991-54	2	-	
21ME14 §	Washington Creek	MHS 1991-55 MHS 1991-294 MHS 1993-132 Mather et al. 1998	2,483	C	
21ME15	Dalson	MHS 1991-56 MHS 1991-295	2	-	

Appendix 3. MINNESOTA, Meeker County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21ME16	--	MHS 1990-400	24	A	
21ME17	Cedar Mills Findspot	MHS 1993-261	2	-	
21ME18 §	Harold	MHS 1993-276	144	A	
21ME28	Thompson Lake Access	Skaar & Gonsior 1999	1	-	
21ME	Miller	MHS 1994-90	10	-	

Appendix 3. MINNESOTA, Mille Lacs County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21ML6 §	Indian School	MHS IL1994-1	765	C	
21ML9 §	Cooper	MHS 2003-039 Bakken 2003	927	C	
21ML11	Petaga Point	Bleed 1969	5,348	*	
21ML11 §	Petaga Point	MHS 1994-119 MHS 1999-212 MHS 1999-216 MHS 1999-290	107	-	
21ML15 §	Father Hennepin SP I	MHS 1997-94 Gonsior 1998	325	C	Brainerd component?
21ML15 §	Father Hennepin SP I	MHS 1998-264	148	C	Multiple Woodland components?
21ML15	Father Hennepin SP I	MHS 1994-120	1	P	
21ML31 §	Portage Bay Mounds	MHS 1988-362 Kluth & Kluth 1996	201	C	
21ML33 §	Crosier	MHS 1988-363 MHS 1990-12	1,544	-	
21ML33 §	Crosier S	MHS 1997-994	376	C	
21ML33+ §	Crosier N and Litke / Anderson	MHS 1997-994 MHS 1997-996	386	-	
21ML36 §	Old Onamia Beach I	MHS 1988-364 MHS 1997-995 Kluth & Kluth 1996	144	-	
21ML37 §	Van Grinsven 1	MHS 1988-365 MHS 1988-366 MHS 1990-13 MHS 1997-999	569	-	
21ML39 §	Onamia View	MHS 1988-367 MHS 1989-536 Westover 1996	616	-	

Appendix 3. MINNESOTA, Mille Lacs County

Site No.	Site Name	Reference	n=	+	Context
21ML40 §	Black Brook	MHS 1988-368 MHS 1990-14 MHS 1990-398 MHS 1997-998	126	-	
21ML41 §	Ben & Fern Larson	MHS 1988-369 MHS 1990-15	115	A	
21ML42 §	Bradbury Brook	Malik & Bakken 1999	126,852	P	
21ML43	Old Onamia Beach II	MHS 1990-8 MHS 1997-997 Kluth & Kluth 1996	23	-	
21ML44	Onamia Portage I	MHS 1990-9	2	-	
21ML45	Onamia Portage II	MHS 1990-10 Kluth & Kluth 1996	3	-	
21ML46	Konfheir Pit	MHS 1991-6	5	-	
21ML47 §	Rum River Pit	MHS 1991-7	158	-	
21ML50	118th Avenue	Kluth & Kluth 1996	6	-	
21ML51	Petrin	Kluth & Kluth 1996	16	-	
21ML52	Jones	Kluth & Kluth 1996	26	C	
21ML53	Powerline	Kluth & Kluth 1996	34	A	
21ML54	South Harbor Ridge	Kluth & Kluth 1996	20	A	
21ML55 §	Upper South Harbor	Kluth & Kluth 1996	149	A	
21ML63	Rum River Terrace	MHS 1996-200	4	-	
21ML64	Kathio SP II	MHS 2000-141	2	-	
21ML68	Shah-Bush-Kung Bay	MHS 1989-420	5	C	
21ML72	Onamia Timber Sale I	MHS 1996-497	19	C	
21ML73	Onamia Timber Sale II	MHS 1996-498	13	-	
21ML74	Onamia Timber Sale III	MHS 1996-499	3	C	
21ML79 §	Ogechie Lake Trail	MHS 1995-34	106	C	
21ML81 §	--	Trocki 2002, 2003a, 2003b	4,070	-	
21ML96	Group Camp	MHS 2000-29	18	A	

Appendix 3. MINNESOTA, Mille Lacs County

Site No.	Site Name	Reference	n=	+	Context
21ML	--	SMM (ident. for private collector)	1	-	

Appendix 3. MINNESOTA, Morrison County

Site No.	Site Name	Reference	n=		Context
21MO13	Morey	UM 695	27	C	
21MO15	Steinbrecher	MHS 198-20	1,420	*	
21MO47	Camp Ripley	MHS 1993-63	2	-	
21MO48	--	MHS 1993-64	1	-	
21MO52	--	MHS 1993-66	1	-	
21MO54	Old Barn (same as MO55)	MHS 1990-308 MHS 1992-16	31	x	
21MO56 §	--	Harrison 1995	27,123	x	
21MO56	--	MHS 1992-17	22	x	
21MO57	--	MHS 1992-19	1	-	
21MO58	--	MHS 1992-20	5	-	
21MO60	--	MHS 1992-22	1	-	
21MO62	--	MHS 1992-18	3	x	
21MO63	--	MHS 1992-21	7	x	
21MO64	Vait FS	MHS 1992-230	1	x	
21MO65	North Platte River	MHS 1990-329	5	-	
21MO67	--	Winham et al. 1994	1	C	
21MO114 §	Kruger	Harrison 1994a, 1994b	3,456	x	
21MO120	Lindbergh Farm	Steiner & Clouse 1997	89	x	
21MO	--	MHS 1990-309	6	-	
21MO §	--	UM 328	242	x	

Appendix 3. MINNESOTA, Mower County

Site No.	Site Name	Reference	n=	+	Context
21MW1	Sleeper	UM 219	11	-	
21MW4	--	UM 658	2	C	
21MW16	North Fork Bear Creek	MHS 1991-81	7	A	
21MW17	Sample	MHS 1991-80	3	A	
21MW18 §	Sherbun's Creek	MHS 1993-302	574	x	

Appendix 3. MINNESOTA, Mower County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21MW19	Bear Creek Findspot	MHS 1993-267	1	-	
21MW20?	--	MHS 1993-266	49	A	
21MW26	Hotson	Forsberg et al. 1999	38	x	
21MW30	Shooting Star 1	MHS 1996-294	8	A	
21MW31	Shooting Star 2	MHS 1996-295	64	C	
21MW32	Shooting Star 3	MHS 1996-296	1	-	
21MW33	Lake Louise	MHS 2004-110	1	-	
21MW35 §	--	Forsberg et al. 1999	1,701	x	
21MW36	--	Forsberg et al. 1999	61	C	
21MW37	Shooting Star 4	MHS 1999-430	48	A	
21MW38 §	Shooting Star 5	MHS 1999-431	173	A	
21MW41	Turtle Lake Overlook	Harrison 2002a	2	-	
21MW42	Lake Louise Campground Site	MHS 2002-225	9	-	
21MW	Lake Louise	MHS 1996-293	40	A	

Appendix 3. MINNESOTA, Murray County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21MU1	Big Slough	UM 598	68	-	
21MU3	Lake Shetek 1	UM 239 Bakken et al. 2007	35	C	
21MU10 §	Smith Lake	MHS 1994-190 MHS 1995-206	110	C	
21MU35	Lake Shetek Campground Site	MHS 1997-260	5	C	
21MU36	Group Camp	MHS 1987-182	5	C	
21MU39	--	Bakken et al. 2007	1	-	
21MU39	Bangasser / Anderson	MHS 1991-63 MHS 1992-380 Bakken et al. 2007	137		
21MU43	--	MHS 1995-205	3	-	
21MU46	Holland	MHS 1991-202	11	-	
21MU50	Lake Shetek SP Fish Pond No. 2	MHS 1995-207 MHS 1996-312	55	A	
21MU51	Lake Shetek SP Shop	MHS 1995-208	31	A	
21MU53	--	Bakken et al. 2007	4	C	

Appendix 3. MINNESOTA, Murray County

Site No.	Site Name	Reference	n=	+	Context
21MU56	Madsen-Shetek	UM 229 MHS 1992-429 Bakken et al. 2007	58	C	
21MU57	Shetek-Armstrong Access Site I	MHS 1999-219 MHS 1999-481	29	V	
21MU58	Shetek-Armstrong Access II	MHS 1999-220 MHS 1999-482	3	-	
21MU59	Shetek-Armstrong Access III	MHS 1999-221 MHS 1999-483	2	-	
21MU61	--	Bakken et al. 2007	7	C	
21MU69	--	Bakken et al. 2007	1	C	
21MU70	--	Bakken et al. 2007	1	-	
21MU71	--	Bakken et al. 2007	2	-	
21MU72	--	Bakken et al. 2007	1	-	
21MU73	--	Bakken et al. 2007	1	-	
21MU74	--	Bakken et al. 2007	1	-	
21MU75	--	Bakken et al. 2007	3	-	
21MU76	--	Bakken et al. 2007	2	-	
21MU77	--	Bakken et al. 2007	1	-	
21MU78	--	Bakken et al. 2007	1	-	
21MU79	--	Bakken et al. 2007	18	C	
21MU80	--	Bakken et al. 2007	25	C	
21MU81	--	Bakken et al. 2007	3	-	
21MU82	--	Bakken et al. 2007	2	-	
21MU83	Deerpath Road	Bakken et al. 2007	412	-	TU 1, 2
21MU84	Teepeeotah Road	Bakken et al. 2007	113	-	TU 1, 2, 3
21MU85	--	Bakken et al. 2007	4	-	
21MU86	--	Bakken et al. 2007	3	C	
21MU	Lake Shetek Campground Site 2	MHS 1997-291	3	-	
21MU	--	Bakken et al. 2007	1	-	

Appendix 3. MINNESOTA, Nicollet County

Site No.	Site Name	Reference	n=	+	Context
21NL1	Poehler	UM 384	6	C	
21NL8	Fort Ridgely	MHS 1987-186	1	-	

Appendix 3. MINNESOTA, Nicollet County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21NL35	Lithic Scatter	MHS 1988-380 MHS 1991-32	7	-	
21NL47	Minnemishona Falls	MHS 1994-96	8	C	
21NL48	Fort Ridgely Creek	MHS 1987-183	5	x	
21NL54	Swan Lake II / Swan Lake Outlet Findspot	MHS 1988-385	1	*	
21NL55	Sellner	MHS 1988-381 MHS 1990-32	26	*	
21NL56	Old Channel	MHS 1988-383 MHS 1990-33	8	*	
21NL57	Sellner Findspot	MHS 1988-384	1	-	
21NL58 §	Altman	MHS 1988-386 MHS 1990-34 MHS 1991-33 Terrell et al. 2005	160	A	
21NL59 §	New Ulm Conglomerate	MHS 1990-35 Terrell et al. 2005	495	-	
21NL62	Fritsche Creek I	MHS 1990-279	88	A	
21NL63	Fritsche Creek Bison Kill	MHS 1990-280	9	A	
21NL64 §	Heymans Creek	MHS 1991-42	190	C	
21NL65	Powers	MHS 1993-335	41	x	
21NL66	Rogers Creek	MHS 1993-129	1	-	
21NL67	Barney Fry Creek	MHS 1993-130	4	x	
21NL69 §	Trivium	MHS 1993-300	149	x	
21NL73	Travers de Sioux	MHS 2000-49	54	x	
21NL117	--	Forsberg et al. 1999	23	x	

Appendix 3. MINNESOTA, Nobles County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21NO3	Leopold Farm	UM 585 MHS 1989-504	13	*	
21NO4 §	Fury Island	UM 586	111	C	
21NO40	Aeriation	MHS 1989-505	8	*	
21NO41	Speth	MHS 1989-506	22	*	
21NO44	Shobaken	MHS 1991-416 MHS 1992-137	49	A	
21NO45 §	Lynn	MHS 1991-417	141	A	

Appendix 3. MINNESOTA, Nobles County

Site No.	Site Name	Reference	n=	+	Context
21NO	Indian Lake	MHS 1995-11	6	-	

Appendix 3. MINNESOTA, Norman County

Site No.	Site Name	Reference	n=	+	Context
21NR1 §	Slininger	UM 270 MSUM collections	338	C	
21NR2	Habben	UM 271	15	C	
21NR3 §	Natwick	MSUM collections	448	C	
21NR9	Canning	Michlovic 1986	47	C	Upper
21NR9 §	Canning	Michlovic 1986	1,196	A	Lower
21NR9	Canning	Michlovic 1986	35	-	Other
21NR10	K. Sheer (contains 21NR38)	UM 702-29	15	-	
21NR11	Nelson-Ziegler-Streed	UM (not accessioned)	10	C	
21NR13	E. Nelson II	MSUM collections 203-5	3	C	
21NR14	A. Ziegler	MSUM collections 203-6	2	C	
21NR15	D. Borgen	MSUM collections 203-7	11	C	
21NR16	L. Hoff I	MSUM collections 203-8	7	C	
21NR17	O. Olson	MSUM collections 203-9	16	C	
21NR18	W. Borgen	MSUM collections 203-10	3	C	
21NR19	Canning's Loop I	MSUM collections 203-11	7	C	
21NR20	Canning's Field I	MSUM collections 203-12	2	C	
21NR21	L. Hoff II	MSUM collections 203-13	3	C	
21NR22	Canning's Field II	MSUM collections 203-14	5	C	
21NR24	Canning's Loop III	MSUM collections 203-16	8	C	
21NR25	Canning's Loop IV	MSUM collections 203-17	9	C	

Appendix 3. MINNESOTA, Norman County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21NR26	H. Ystebo I	MSUM collections 203-18	23	C	
21NR27	H. Ystebo II	MSUM collections 203-19	2	C	
21NR28	R. Arneson I	MSUM collections 203-20	14	C	
21NR29 §	Mooney	Michlovic 1987	255	C	Upper component
21NR29	Mooney	Michlovic 1987	24	A	Lower component
21NR32	J. & B. Furuseth	MSUM collections	1	C	
21NR33	E. Tronnes I	MSUM collections 203-25	12	C	
21NR34	Meander	MSUM collections 203-26	6	C	
21NR35	G. Rude	MSUM collections 203-27	3	C	
21NR36	E. Tronnes II	MSUM collections 203-28	5	C	
21NR37	A. Serum	MSUM collections	1	C	
21NR38	Canning's Loop V	MSUM collections	27	C	
21NR41	R. Arneson II	MSUM collections	4	C	
21NR44	R. Paulsrud	MSUM collections 203-38	5	C	
21NR45	E. Tronnes III	MSUM collections 203-39	5	C	
21NR47	R. Arneson III	MSUM collections 203-41	1	C	
21NR48	L. Peterson I	MSUM collections 203-42	1	C	
21NR49	R. Arneson IV	MSUM collections 203-43	1	C	
21RN50	R. Arneson V	MSUM collections 203-44	4	C	
21NR51	Razed Farm Site	MHS 1991-108	4	-	
21NR58	Perley Bridge FS	MHS 1989-465	1	-	

Appendix 3. MINNESOTA, Olmsted County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21OL2	Oxbow Park	UM 885	36	C	
21OL21	Muenter I	MHS 1997-163	16	C	

Appendix 3. MINNESOTA, Olmsted County

Site No.	Site Name	Reference	n=	+	Context
21OL22	Muenter II	MHS 1997-164	31	C	

Appendix 3. MINNESOTA, Otter Tail County

Site No.	Site Name	Reference	n=	+	Context
21OT2	Morrison	UM 173	1	-	
21OT5	Graham Lake	UM 304	4	-	
21OT73	Deer Lake	MHS 1990-142	18	*	
21OT86 §	Moore Lake	MHS 1987-5	703	A	
21OT87	Moore Lake East	MHS 1987-6 MHS 1987-83	32	A	
21OT88	Lida Narrows East	MHS 1987-2	16	*	
21OT89	Star Lake West	MHS 1987-4	162	*	
21OT94	Phelps Mill	MHS 1986-290	3	*	
21OT96	Harrom II	MHS 1986-289	32	*	
21OT97	Marion Lake	MHS 1987-306 MHS 1988-350	230	*	
21OT98	Merickel	MHS 1989-485	13	-	
21OT99	Otter Tail / Riverside	MHS 1988-299	55	*	
21OT100	Molly Stark	MHS 1989-507	2	*	
21OT101	Fergus Falls Bypass	MHS 1991-8	14	A	
21OT103	Glendalough Lodge	MHS 2003-212	5	-	
21OT104	Annie Battle Lake	MHS 1996-286 MHS 1997-279 MHS 2003-172	17	C	
21OT105	South Bluff Creek	MHS 1990-399 MHS 1991-186	80	A	
21OT106	Glendalough SP I	MHS 1995-26	2	-	
21OT107	Glendalough SP 2	MHS 1995-25 MHS 1995-163	53	A	
21OT108	Molly Stark Prairie	MHS 1995-24 MHS 1995-164	6	A	
21OT109	Lake Lida	MHS 1994-208 MHS 1994-236	50	C	
21OT111	Glendalough SP III	MHS 1995-165	2	-	
21OT112	Glendalough SP IV	MHS 1995-166	20	C	
21OT113	Glendalough SP V	MHS 1995-167	30	C	
21OT114	Glendalough SP VI	MHS 1995-168	18	A	

Appendix 3. MINNESOTA, Otter Tail County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21OT127	First Silver Lake	MHS 1991-400	7	A	
21OT132 §	Glendalough SP 9	MHS 1997-280	101	C	
21OT139	Glendalough SP 7	Radford et al. 1997	18	C	Upper component
21OT139	Glendalough SP 7	Radford et al. 1997	10	A	Lower component
21OT140	Glendalough SP 8	MHS 1996-439 MHS 2004-192	57	C	
21OT141	Glendalough SP 10	MHS 1997-281	1	-	
21OT148	Glendalough SP 11	MHS 2000-124	1	-	
21OT159	Armor WMA Access Road	MHS 2003-34	2	-	
21OT160	Copeland	MHS 2003-35	1	-	
21OT164	Glendalough SP 12	MHS 2004-193	4	-	
21OT169	Rose Lake	Vermeer 2005	6	C	
21OT-FS4	County Road 51	MHS 1989-486	4	-	

Appendix 3. MINNESOTA, Pennington County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21PE2	Squaw Point	MHS 1988-54	243	*	
21PE2	Squaw Point	Mulholland et al. 1996; Mulholland et al. 2002b	70	C	
21PE7	Findspot	MHS 206-3-1	1	-	
21PE8	--	Breakey et al. 1994	13	*	
21PE9	--	Mulholland et al. 1996	1	-	
21PE10	--	Mulholland et al. 1996	1	-	
21PE11	--	Mulholland et al. 1996	1	C	
21PE12	--	Mulholland et al. 1996	1	-	
21PE13	--	Mulholland et al. 1996 Mulholland et al. 1998	23	C	
21PE14	Old Coulee	Mulholland et al. 1996; Mulholland et al. 2002b	62	C	

Appendix 3. MINNESOTA, Pennington County

Site No.	Site Name	Reference	n=	+	Context
21PE15	--	Mulholland et al. 1996	1	-	
21PE16	--	Mulholland et al. 1996	1	-	
21PE17	Thornbush	Mulholland et al. 1996; Mulholland 2002b	7	C	
21PE18	Boy Scout Camp	Mulholland et al. 1996; Mulholland 2002b	74	C	
21PE19	--	Mulholland et al. 1996;Mulholland et al. 1998	16	C	
21PE20	--	Mulholland et al. 1996	1	C	
21PE21	--	Mulholland et al. 1996	1	-	
21PE22	--	Mulholland et al. 1996	1	-	

Appendix 3. MINNESOTA, Pine County

Site No.	Site Name	Reference	n=	+	Context
21PN10	Pokegama Outlet	MHS 1989-424	35	C	
21PN11 §	Northwest Company Post	Bakken 2002b	1,344	-	
21PN16	Little Yellow Banks	MHS 1999-215	1	-	
21PN17 §	Winter	Johnson 1993	1,577	x	
21PN46	B.P. Vadnais	MHS 1993-268 MHS 1995-192	84	C	
21PN57	Cross Lake	MHS 1992-387 MHS 1988-349	50	*	
21PN58	J. Miller	MHS 1991-385	10	A	
21PN59	Pine City Rest Area Findspot	MHS 1990-5	1	-	
21PN83 §	McCormick Lake	MHS 1999-487	171	C	
21PN83	McCormick Lake	MHS 1999-487	10	A	
21PN84 §	Dago Lake	MHS 2000-114	110	A	
21PN85	Dago Beach Findspot	MHS 2000-115	1	P	

Appendix 3. MINNESOTA, Pine County

Site No.	Site Name	Reference	n=	+	Context
21PN86 §	R&D Neubauer	Romano & Mulholland 2000	1,847	-	

Appendix 3. MINNESOTA, Pipestone County

Site No.	Site Name	Reference	n=	+	Context
21PP25	Disappointing	McFarlane 1998	1	-	
21PP26	Kallemeyn	McFarlane 1998	1	-	
21PP27	Split Rock Creek SP	MHS 1994-122	41	A	
21PP33	Francis Jr. Site	McFarlane 1998	1	-	
21PP34	Bouman	McFarlane 1998	1	-	
21PP35	LeVon Henry	McFarlane 1998	4	-	
21PP36	Gangstad	McFarlane 1998	1	-	
21PP37	Gopher Trap	McFarlane 1998	1	-	
21PP38	Vander-Sluis	McFarlane 1998	12	-	
21PP40	Brands	McFarlane 1998	1	-	
21PP41	Vannieuwenhuzen	McFarlane 1998	1	-	
21PP42	Snack	McFarlane 1998	6	-	
21PP44	Alderson	McFarlane 1998	1	-	
21PP45	Barke	McFarlane 1998	2	-	
21PL46	Pipestone 1	Mulholland et al. 2000	4	-	
21PP47	--	McFarlane 1998	4	-	

Appendix 3. MINNESOTA, Polk County

Site No.	Site Name	Reference	n=	+	Context
21PL3	Engel	MHS 346-21	8	-	
21PL6	Warner	UM 112 Thompson 1985	88	C	
21PL8	Sather	UM 480	250	A	
21PL9	Crookston	UM 479	7	C	
21PL13	Peter Lee	MHS 209-2	6	C	
21PL14	Badger Lake	MHS 209-2 MHS 2003-233	86	A	
21PL15	Oak Lake	MHS 209-3	1	-	
21PL16	McBurney	MHS 209-12 MHS 483-2 MHS 1992-196	33	C	

Appendix 3. MINNESOTA, Polk County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21PL19	Garden Township Road	MHS 1992-197	45	A	
21PL20	Erskine Infiltration Basin	MHS 1993-289	2	-	
21PL21	Clausen Lake	MHS 1993-288	83	A	
21PL27	Grabonsky	MHS 1991-318 MHS 1992-123	13	C	
21PL28	Grand Marais Creek	MHS 1992-130	10	C	
21PL48	--	Florin et al. 2001	22	C	
21PL49	--	Florin et al. 2001; Florin & Wergin 2001	28	C	
21PL49	--	Florin et al. 2001	5	A	
21PL50	Peabody	Florin et al. 2001	8	C	
21PL54 §	--	Florin et al. 2001	93	x	
21PL54	--	Florin et al. 2001	10	A	
21PL55	--	Larson & Penny 2000	1	-	
21PL56	--	Larson & Penny 2000	1	-	
21PL57	--	Florin et al. 2001	27	A	
21PL57 §	--	Florin et al. 2001	433	x	
21PL59	--	Larson & Penny 2000	3	-	
21PL60	--	Larson & Penny 2000; Florin et al. 2001	6	-	
21PL62	--	Florin et al. 2001	5	C	
21PL63	--	Florin et al. 2001	1	-	
21PL64	--	Florin et al. 2001	3	-	
21PL65	--	Florin et al. 2001	1	-	
21PL66 §	--	Florin et al. 2001	101	x	
21PL66	--	Florin et al. 2001	44	-	
21PL67	--	Florin et al. 2001	13	-	
21PL68	--	Florin et al. 2001	40	-	
21PL69	--	Florin et al. 2001	31	C	
21PL71	--	Florin et al. 2001	33	C	
21PL72	--	Harvey et al. 2005	5	C	
21PL74	--	Harvey et al. 2005	64	C	

Appendix 3. MINNESOTA, Polk County

Site No.	Site Name	Reference	n=	+	Context
21PL83	--	Florin & Wergin 2004	10	C	
21PL85	--	Florin & Wergin 2004	1	A	Middle component
21PL85	--	Florin & Wergin 2004	59	x	Lower component
21PL	--	UM 740-1	3	-	

Appendix 3. MINNESOTA, Pope County

Site No.	Site Name	Reference	n=		Context
21PO3	Pelican Lake Gravel Pit Site	UM 380	2	A	
21PO24 §	Lake Emily	MHS 1995-321	213	C	
21PO25	Signalness Lake	MHS 2001-182	15	A	
21PO26	--	Nienow & Breakey 2002	1	-	
21PO27	--	Nienow & Breakey 2002	1	-	

Appendix 3. MINNESOTA, Ramsey County

Site No.	Site Name	Reference	n=	+	Context
21RA16	Hillcrest	Harrison 1992	1	-	
21RA31	Snail Lake	Forsberg 1995	42	C	
21RA	CoPar S	Vermeer & Bakken 2005	1	-	
21RA	CoPar N	Vermeer & Bakken 2005	4	C	

Appendix 3. MINNESOTA, Red Lake County

Site No.	Site Name	Reference	n=	+	Context
21RL1	Red Lake River	UM 150	29	C	
21RL3	Sportsmans' Park	UM 740-3	9	*	

Appendix 3. MINNESOTA, Redwood County

Site No.	Site Name	Reference	n=	+	Context
21RW52	Crow Creek	MHS 1988-388 MHS 1989-532	30	V	
21RW53	J-squared / Jackpot Junction	MHS IL1989-8 Justin & Peterson 1991; Bower et al. 1996	65	A	

Appendix 3. MINNESOTA, Redwood County

Site No.	Site Name	Reference	n=	+	Context
21RW54	Sulphur Lake	MHS 1989-531 MHS 1991-402	3	-	
21RW57 §	Batzlaff	MHS 1992-119	103	A	

Appendix 3. MINNESOTA, Renville County

Site No.	Site Name	Reference	n=	+	Context
21RN19	Thorkelson	MHS 1988-391 Gonsior & Yourd 1990	22	A	Upper component
21RN19 §	Thorkelson	MHS 1988-391 Gonsior & Yourd 1990	279	P	Lower component
21RN19	Thorkelson	MHS 1985-51 MHS 1987-11 MHS 1988-42	119	*	Lower quality data
21RN20 §	Hawk Creek	MHS 1988-390 MHS 1991-51 Gonsior & Yourd 1990	375	A	Higher quality data
21RN20	Hawk Creek	MHS 1985-52 MHS 1988-41	36	*	Lower quality data
21RN21	Morton River Crossing	MHS 1988-55	6	-	
21RN23	Vait Findspot	MHS 1992-230	1	-	
21RN	--	MHS 1993-272	1	-	

Appendix 3. MINNESOTA, Rice County

Site No.	Site Name	Reference	n=	+	Context
21RC38	Union Lake	MHS IL1988-6	5	A	
21RC39	Hidden Falls	MHS 1994-123	7	A	
21RC40	Valek	MHS 1991-189	13	A	
21RC41	Casey Jones	MHS 1991-190	5	A	
21RC42	Wetlands Outlet	MHS 1991-191 MHS 1999-223	37	x	
21RC64	Blue Mounds SP Group Camp	MHS 1995-209	3	A	
21RC	Shieldville	Elquist 2005	3	-	

Appendix 3. MINNESOTA, Rock County

Site No.	Site Name	Reference	n=	+	Context
21RK8	Blue Mound	UM 717-6	13	-	

Appendix 3. MINNESOTA, Rock County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21RK9	Keizer I	UM 717-16	11	-	
21RK10	Manfred	UM 717-n	13	-	
21RK12	--	UM 717-14	21	-	
21RK13	--	UM 717-15	16	-	
21RK14	--	UM 717-22	56	-	
21RK43	Manley	MHS 1989-487	2	-	
21RK44	Curtis Rollag	MHS 1994-147	1	-	
21RK45	Kelm I	MHS 1994-148	1	-	
21RK46	Kelm II	MHS 1994-149	2	-	
21RK47	Gulseth	MHS 1994-150	71	A	
21RK48	Leonard Rollag	MHS 1994-151	1	-	
21RK49	Bergin I	MHS 1994-152	4	-	
21RK50	Reker	MHS 1994-153	1	-	
21RK51	Bergin II	MHS 1994-154	1	-	
21RK52	Stegena	MHS 1994-155	2	-	
21RK53	Ergin	MHS 1994-156	1	-	
21RK54	Lois Raths	MHS 1994-157	2	-	
21RK55	Tilda Larson	MHS 1994-163	1	-	
21RK66	Blue Mound Campground	MHS 2003-150	1	-	

Appendix 3. MINNESOTA, Roseau County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21RO2	Johnson	UM 495 Bakken notes	13	A	
21RO4?	Ross Indian Village	UM 280	39	C	
21RO5	Magnussen?	UM 654	485	*	
21RO7	Lins	UM 496	2	-	
21RO11 §	Greenbush Borrow Pit	MHS 330 Peterson 1973	4,238	P	
21RO12	Campbell Beach	MHS 1970-489 Nystuen & Peterson 1972	21	-	
21RO21 §	Erickson	Bakken 1988	561	x	
21RO23	Severson	MHS 1994-202	2	-	
21RO34	--	Florin 2003	9	A	

Appendix 3. MINNESOTA, Roseau County

Site No.	Site Name	Reference	n=	+	Context
21RO35	--	Florin 2003	1	-	
21RO	Ten Mile Corner	Ident. of private collection (L. Erickson)	8	-	
21RO	--	MHS 426	7	-	
21RO	Branvold	M. Magner, pers. comm. 1990	71	P	
21RO	Point Bar	Ident. of private collection (M. Gehrke), Bakken notes	49	C	

Appendix 3. MINNESOTA, St. Louis County

Site No.	Site Name	Reference	n=	+	Context
21SL16	ER-29 / Nordberg I	Harrison et al. 1995	11	P	
21SL16 §	ER-30 / Nordberg Campground	Harrison et al. 1995	636	P	
21SL16	ER-28 / Nordberg W	Harrison et al. 1995	91	P	
21SL151	Minnesota Point	UM 377	2	*	
21SL259 ?	ER-22 / Bridge 2	Harrison et al. 1995	9	P	
21SL274 §	Side Lake Beach	MHS 1992-436 MHS 1995-27 MHS 1998-396 MHS 1999-342 Gonsior 2002	778	-	
21SL275	Pike River Falls	MHS 1991-320	13	C	
21SL285	ER-19 / Boulder-Carlson	Harrison et al. 1995	28	P	
21SL288	ER-06 / Stump A	Harrison et al. 1995	66	P	
21SL331	ER-41 / Moose	Harrison et al. 1995	3	P	
21SL337	ER-40 / Christmas Tree Island	Harrison et al. 1995	6	P	
21SL366 §	ER-03 / Animal Island	Harrison et al. 1995	569	P	
21SL582	Shannon Lake	Gonsior 2002	5	-	
21SL771 §	County Road 915	MHS 1999-501 MHS 2000-128 Gonsior 2002	495	A	
21SL777	State Point	MHS 1999-469	3	-	
21SL778	Duck Bay Retreat	MHS 1999-451	9	-	

Appendix 3. MINNESOTA, St. Louis County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SL779	State Point Island	MHS 1999-452	1	-	
21SL781	Saunder's Bay	MHS 1999-466	12	-	
21SL782	Pelican Point I	MHS 1999-464	2	C	
21SL783	Pelican Point II	MHS 1999-465	5	C	
21SL785 §	God's Little Acre	MHS 1999-446	148	C	TU 2
21SL785	God's Little Acre	MHS 1999-446	101	C	TU 1, ST 2
21SL787	Schmidt's Island	MHS 1999-468	27	A	
21SL788	Cozy Cay	MHS 1999-443	6	C	
21SL789	Oak Narrows	MHS 1999-462	15	A	
21SL790	Hoff Island West	MHS 1999-453	66	A	
21SL791	Hoff Island East	MHS 1999-545	19	A	
21SL793	Shively Falls Portage Camp	MHS 1996-500 MHS 1997-350	13	C	
21SL794	Shively Falls Portage	MHS 1997-351	1	C	
21SL795	Campsite 4	MHS 1996-502	7	C	
21SL796	Table Rock Falls	MHS 1996-503 MHS 1997-353	83	C	
21SL797	Table Rock Portage	MHS 1996-504	1	-	
21SL798	Buyck Brothers	MHS 1996-505 MHS 1997-354	7	-	
21SL840	Shively Landing	MHS 1997-355	4	C	
21SL842	Sturgeon Lake	MHS 1998-415 MHS 1999-354 Gonsior 2002	95	A	
21SL920	Sturgeon Lake Beach	MHS 2003-123	38	C	
21SL928	ER-17 / Nordberg 3	Harrison et al. 1995	40	P	
21SL945	Side Lake Campground	MHS 2003-124	43	-	
21SL	ER-01 / Government Island	Harrison et al. 1995	61	P	
21SL §	ER-02 / Orchard	Harrison et al. 1995	444	P	
21SL §	ER-05 / Thompson	Harrison et al. 1995	3,514	P	
21SL §	ER-07 / Palmer	Harrison et al. 1995	2,126	P	
21SL §	ER-08 / Nordberg #2	Harrison et al. 1995	519	P	
21SL	ER-09 / Oman	Harrison et al. 1995	2	P	
21SL §	ER-10 / Bridge Island	Harrison et al. 1995	312	P	

Appendix 3. MINNESOTA, St. Louis County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SL §	ER-11 / Stump	Harrison et al. 1995	654	P	
21SL §	ER-12 / Bridge	Harrison et al. 1995	2,941	P	
21SL §	ER-13 / Breezy Point	Harrison et al. 1995	641	P	
21SL	ER-14 / Johnson	Harrison et al. 1995	54	P	
21SL	ER-15 / Thompson-Reisland	Harrison et al. 1995	6	P	
21SL §	ER-16 / Thompson-Reisland Island	Harrison et al. 1995	310	P	
21SL	ER-18 / Stumps Stumps Stumps	Harrison et al. 1995	123	P	
21SL	ER-20 / Thompson-Reisland Island I & II	Harrison et al. 1995	149	P	
21SL	ER-21 / Thompson-Reisland-Thompson	Harrison et al. 1995	504	P	
21SL	ER-24 / Vern's Place	Harrison et al. 1995	49	P	
21SL	ER-25 / Palmer 1	Harrison et al. 1995	241	P	
21SL	ER-27 / Fayling	Harrison et al. 1995	15	P	
21SL	ER-32 / Vern's 1	Harrison et al. 1995	39	P	
21SL §	ER-33 / Vern's 2	Harrison et al. 1995	151	P	
21SL	ER-34 / Bridge 3	Harrison et al. 1995	36	P	
21SL §	ER-35 / Nordberg E	Harrison et al. 1995	387	P	
21SL	ER-36 / Trout Pond	Harrison et al. 1995	5	P	
21SL	ER-37 / Animal Island East	Harrison et al. 1995	2	P	
21SL	ER-38 / Burkes Place	Harrison et al. 1995	5	P	
21SL	ER-39 / Rock Island	Harrison et al. 1995	83	P	
21SL	ER-42 / Church Island	Harrison et al. 1995	3	P	
21SL	River Point	Mulholland & Shafer 2000	4,238	-	

Appendix 3. MINNESOTA, Scott County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SC1	Huber	UM 232	41	C	
21SC33	Murphy's Landing Terrace	MHS 2001-422	13	A	
21SC38	Sand Dune	MHS 2004-213	5	-	

Appendix 3. MINNESOTA, Scott County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21SC52 §	Blackberry Patch Mounds & Habitation	MHS 1997-261	267	C	
21SC64	Malkerson	Mather 2000	9	-	
21SC72	Shenandoah Park	Harrison 2001b	12	A	
21SC75	Blue Lake 1	MHS IL2001-34	34	A	
21SC76	Blue Lake 2	MHS 2001-425	5	A	
21SC79	Blue Lake 5	MHS IL2001-37	57	C	
21SC80	Blue Lake 6	MHS IL2001-38	57	C	
21SC91	Highway 41 Trail	MHS 2004-191	3	-	
21SC92	Sioux Vista Trail	MHS 2004-214	1	-	

Appendix 3. MINNESOTA, Sherburne County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21SH15 §	Honker	Higginbottom & Henning 1997	882	C	Mound A
21SH15 §	Honker	Higginbottom & Henning 1997	1,881	C	Mound B
21SH15 §	Honker	Higginbottom & Henning 1997	175	C	Mound F
21SH15 §	Honker	Higginbottom & Henning 1997	633	C	Village Area
21SH18 §	Refuge	Higginbottom & Henning 1997	4,487	C	Cluster 1
21SH18 §	Refuge	Higginbottom & Henning 1997	589	C	Cluster 2
21SH18 §	Refuge	Higginbottom & Henning 1997	827	C	Mound 26
21SH18 §	Refuge	Higginbottom & Henning 1997	146	C	Village Area
21SH26	Orrock	MHS 1992-449	6	C	
21SH-ax	Blue Hill	Higginbottom & Henning 1997	1	-	
21SH-bb	L2	Higginbottom & Henning 1997	17	C	
21SH-bh	Eagle Lake	MHS 220-2	10	*	

Appendix 3. MINNESOTA, Sibley County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21SB6 §	--	MHS 1989-508	99	C	

Appendix 3. MINNESOTA, Sibley County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SB15	Hartman	MHS 1989-488	8	-	
21SB16	Berge Lakebed	MHS 1991-290	2	-	

Appendix 3. MINNESOTA, Stearns County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SN14 §	Gardner	MHS 1985-42 MHS 1985-212 BRW 1994	266	C	
21SN15	Richmond Crossing	MHS 1985-43 MHS 1988-44	33	*	
21SN18 §	Rice Lake Water Access	MHS 1990-466 MHS 1991-403 MHS 1996-440	163	*	
21SN20	School Section Lake	MHS 1995-111	1	-	
21SN31	--	MHS 1990-278	1	-	
21SN139	Voight Field 1	Justin et al. 2002	1	-	
21SN140	Voight Field 2	Justin et al. 2002	1	-	
21SN	Field Site A	Hohman-Caine & Goltz 2002d	38	C	
21SN	Field Site B	Hohman-Caine & Goltz 2002d	11	A	
21SN	Field Site C	Hohman-Caine & Goltz 2002d	26	C	
21SN	Field Site D	Hohman-Caine & Goltz 2002d	72	C	
21SN §	Field Site E	Hohman-Caine & Goltz 2002d	155	C	
21SN §	Field Site F	Hohman-Caine & Goltz 2002d	137	C	
21SN	--	MHS 1992-356	2	C	

Appendix 3. MINNESOTA, Steele County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21ST6	Crane Creek	MHS 1991-195	1	-	

Appendix 3. MINNESOTA, Stevens County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SE8	Martin	MHS 1992-370	46	A	
21SE9	Hentges	MHS 1992-120 MHS 1995-13	9	A	

Appendix 3. MINNESOTA, Stevens County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SE10	Moser	MHS 1992-372	6	A	
21SE11	Schmidgall	MHS 1992-371	15	A	
21SE12	Wulf	MHS 1993-150 MHS 1994-200	11	A	
21SE16 §	Van Zomeren	Forsberg et al. 1999; Murray 2000	749	A	
21SE45	Coleman Slough	Emerson & Magner 2005	12	A	

Appendix 3. MINNESOTA, Swift County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21SW9	Hassel	MHS 1985-64	1	-	
21SW14 §	Monson Lake SP Campground	MHS 2000-125	290	x	
21SW	--	MHS 1999-504	19	A	

Appendix 3. MINNESOTA, Todd County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21TO2 §	Mossman Mounds	MHS 1991-327	156	A	
21TO8	Latimer Lake	MHS 1988-348	19	*	
21TO11	Fischer	MHS 1990-7	57	-	
21TO12	Birch Channel	MHS 1991-109	25	C	
21TO13	Little Birch Lake	MHS 1991-110	54	C	
21TO14	Birch Ridge	MHS 1991-328	29	C	
21TO15 §	Brinkman	MHS 1991-329	146	A	
21TO16	--	MHS 1993-269	1	-	
21TO17	--	MHS 1993-270	1	-	
21TO24	Little Sauk Lake Access	MHS 2000-194	44	A	

Appendix 3. MINNESOTA, Traverse County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
21TR1	Round	UM 111	27	-	
21TR2	Wilson	UM 113	1	-	
21TR3	K Mound Group	UM 114	1	-	Mound 2
21TR4	Fire Mound	UM 115	1	-	
21TR6	Shady Dell	UM 350	36	V	

Appendix 3. MINNESOTA, Traverse County

Site No.	Site Name	Reference	n=	+	Context
21TR76-77 §	--	Forsberg et al. 1999	180	P	

Appendix 3. MINNESOTA, Wabasha County

Site No.	Site Name	Reference	n=	+	Context
21WB55	Dutchman Coulee	MHS 1988-2	2,607	*	
21WB56 §	King Coulee	MHS 1988-1 MHS 1988-376 Perkl 1996, 2002	3,044	-	
21WB105	Wilcox Landing Access	MHS 1997-262	30	C	

Appendix 3. MINNESOTA, Wadena County

Site No.	Site Name	Reference	n=	+	Context
21WD6	Blueberry Lake Village	MHS 1990-143	3	*	
21WD6	Blueberry Lake Village	MHS 1990-144 MHS 1992-386 MHS 1993-264	33	C	
21WD9	Shell City Landing	MHS 2002-148 MHS 2003-32	69	C	
21WD11	Twin Lakes East	MHS 1993-262	7	C	
21WD12	Twin Lakes West	MHS 1991-67 MHS 1993-263	21	C	
21WD13	Ferrell	MHS 1990-166	3	C	
21WD20	Huntersville Campground	MHS 1995-316 MHS 1996-506	35	C	

Appendix 3. MINNESOTA, Waseca County

Site No.	Site Name	Reference	n=	+	Context
21WE5	Benson / Arnoldt	MHS 1987-8	10	*	
21WE6	Schweim	MHS 1986-200	381	*	
21WE7	Krienke	MHS 1987-9	4	*	
21WE11	Elysian Beach	MHS 1986-267	4	*	
21WE12	Island	MHS 1986-268	8	*	
21WE14	Iosco Creek	MHS 1986-269	28	A	
21WE15	Cahill	MHS 1990-68	7	-	
21WE19	Old Road	MHS 1990-69	4	-	
21WE20	Roy Keyes	MHS 1988-117	1	*	

Appendix 3. MINNESOTA, Waseca County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21WE22	Goose Lake Access	MHS 1991-29 MHS 1991-196	55	C	
21WE24	Waseca Findspot	MHS 1993-287	1	-	
21WE26	Brase	MHS 1991-194	1	-	
21WE42	--	MHS 1986-266	5	-	
21WE43	Krampitz	MHS 1991-43	5	-	
21WE	Jewison North	MHS 1989-489	2	-	
21WE	Keyes West	MHS 1989-490	3	-	

Appendix 3. MINNESOTA, Washington County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21WA46	Big Marine Lake	MHS 1987-266	3	*	
21WA49 §	St. Croix River Access	MHS 1991-64 MHS 1991-106 MHS 1991-317 MHS 2004-45 Hoffman & Myster 1993	1,042	-	
21WA52	Bone Lake	MHS 1986-167	68	*	
21WA64	Boom Site Rest Area	MHS 1991-65	6	-	
21WA93 §	Cross	Fleming 2002	102,793	x	
21WA	--	UM 297	2	C	

Appendix 3. MINNESOTA, Watonwan County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21WW10	--	Shaffer 1995	2	-	
21WW11	--	Shaffer 1995	1	-	
21WW13	Wood Lake Access	MHS 1996-317	4	-	

Appendix 3. MINNESOTA, Wilkin County					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
21WL1 §	Femco	MSUM collections Fie 1986	263	C	Surface
21WL1 §	Femco	MSUM collections Fie 1986	1,583	-	Excavation
21WL1	Femco	UM 234	6	V	Unclear
21WL1	Femco	MHS 1988-49	4	*	Unclear
21WL2 §	McCaulleyville	MSUM collections	120	V	
21WL10	Ivan Ness No. 1	MSUM collections	15	C	

Appendix 3. MINNESOTA, Wilkin County

Site No.	Site Name	Reference	n=	+	Context
21WL11	Ivan Ness No. 2	MSUM collections	12	C	
21WL12	Ralph Ness	MSUM collections	12	C	
21WL14	Gerald Hanson No. 2	MSUM collections	5	-	
21WL15	Howard Hanson	MSUM collections	4	-	
21WL16	Medford Larson	MSUM collections	12	-	
21WL17	D. & L. Nelson	MSUM collections	84	C	
21WL18	Flavia Lucke No. 1	MSUM collections	21	C	
21WL19	Flavia Lucke No. 2	MSUM collections	2	C	
21WL20	Bob Miller	MSUM collections	2	-	
21WL21	Jewison (Lawrence Tschackert No. 1)	MSUM collections	3	C	
21WL22 §	Lawrence Tschackert No. 2	MSUM collections	99	V	
21WL23	Lawrence Tschackert No. 4	MSUM collections	32	C	
21WL24	Beyer	MSUM collections	73	C	
21WL25	James Walton No. 1	MSUM collections	84	A	
21WL26	James Walton No. 2	MSUM collections	11	C	
21WL27	James Walton No. 3	MSUM collections	83	A	
21WL28	J. Walton No. 4	MSUM collections	38	C	
21WL29	W. Hlubeck	MSUM collections	20	A	
21WL30	V. Radig	MSUM collections	16	C	
21WL32	Breckenridge Bypass	MHS 347	32	*	

Appendix 3. MINNESOTA, Winona County

Site No.	Site Name	Reference	n=	+	Context
21WN1	LaMoille Cave	UM 216 Wilford 1954	18	-	
21WN2	Volkart Mounds	UM 367	5	C	
21WN15	Voight	UM 504	1	A	
21WN51	Schultz	MHS 1993-295	14	C	

Appendix 3. MINNESOTA, Wright County

Site No.	Site Name	Reference	n=	+	Context
21WR16	Bjorkland Lake Northeast	MHS 1994-125	3	*	
21WR47	Dutch Lake	MHS 1987-80	6	-	

Appendix 3. MINNESOTA, Wright County

Site No.	Site Name	Reference	n=	+	Context
21WR49	Lake Maria Picnic	MHS 1992-127 MHS 1992-440	55	A	
21WR50	Mink Lake	MHS 1992-441	9	*	
21WR51	Lake Mari Horse Trail	MHS 1992.442 MHS 1996-437	37	-	
21WR53	Beaver Dam Lake	MHS 1991-53	2	-	
21WR54	Kiphuth	MHS 1992-450	5	-	
21WR55	Bursch I	MHS 1992-451	4	C	
21WR56	Gridely	MHS 1992-452	3	C	
21WR57	Clement	MHS 1992-453	12	C	
21WR58	Putz	MHS 1992-454	15	A	
21WR59	Bursch II	MHS 1992-455	3	-	
21WR60	Slough Lake	MHS 1994-126	6	C	
21WR62	Hayes	MHS 1994-283	2	-	
21WR67	Rattlesnake Bottoms Overlook	MHS 1994-199	4	A	
21WR68	Bersie	Mather et al. 1995	1	P	
21WR73	--	MHS 1992-470	2	-	
21WR75	Lake Maria SP I	MHS 1996-435	17	C	
21WR76	Lake Maria SP II	MHS 1996-436	22	C	
21WR78	--	Vermeer et al. 2008	28	A	
21WR106	Ott	MHS 1990-145	1	-	
21WR122	--	Halverson et al. 2000	28	C	
21WR145	--	Lyon 2004	14	A	
21WR146	--	Lyon 2004	15	A	
21WR161	FS-1	Schmidt & Vermeer 2006	43	A	
21WR162	FS-2	Schmidt & Vermeer 2006	15	C	
21WR170	--	Vermeer et al. 2008	1	C	
21WR171	--	Vermeer et al. 2008	1	-	

Appendix 3. MINNESOTA, Yellow Medicine County

Site No.	Site Name	Reference	n=	+	Context
21YM7	--	MHS 1997-23	1	C	

Appendix 3. MINNESOTA, Yellow Medicine County

Site No.	Site Name	Reference	n=	+	Context
21YM47	Granite Falls Bison Kill	IMA files, Ft. Snelling History Center, MHS	1,772	*	
21YM50 §	Mazomani / Kvistero	MHS 1995-361 Gonsior et al. 1996	102	A	Upper component
21YM50 §	Mazomani / Kvistero	MHS 1995-361 Gonsior et al. 1996	201	A	Middle component
21YM50 §	Mazomani / Kvistero	MHS 1995-361 Gonsior et al. 1996	263	A	Lower component
21YM50 §	Mazomani / Kvistero	MHS 1995-361 Gonsior et al. 1996	100	-	Indeterminant component
21YM50	Mazomani / Kvistero	MHS 1997-24	8	A	Later collection
21YM88	Yellow Medicine River	MHS 1997-25 MHS 1998-128	2	-	
21YM	--	MHS 1994-127	7	*	

Appendix 3. NORTH DAKOTA, Cass County

Site No.	Site Name	Reference	n=	+	Context
32CS16	--	Michlovic 1993; Stubbs et al. 2002	12	A	
32CS31	--	MSUM collections	1	C	
32CS33	--	MSUM collections	2	C	
32CS35	--	MSUM collections	1	-	
32CS36	--	MSUM collections	5	C	
32CS37	--	MSUM collections	3	C	
32CS38	--	MSUM collections	26	C	
32CS39	--	MSUM collections	7	-	
32CS101	Shea	Michlovic & Schneider 1988, 1993	1789	V	
32CS229	--	Stubbs & Ollendorf 2002	47	C	
32SC4475	--	Michlovic 1993; Stubbs et al. 2002	12	A	
32CS4476	--	Michlovic 1993; Stubbs et al. 2002	46	C	
32CS4477	--	Michlovic 1993; Stubbs et al. 2002	200	V	
32CS4478	--	Michlovic 1993	5	V	

Appendix 3. NORTH DAKOTA, Cass County					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
32CS4479	--	Michlovic 1993; Stubbs & Ollendorf 2002	13	-	
32CS4480	--	Michlovic 1993	4	C	
32CS4481	--	Michlovic 1993; Stubbs et al. 2002	27	V	
32CS4482	--	Michlovic 1993; Stubbs et al. 2002	62	V	
32CS4483	--	Michlovic 1993	32	C	
32CS4484	--	Stubbs et al. 2002	25	-	
32CS4485	--	Michlovic 1993; Stubbs et al. 2002	15	A	
32CS4486	--	Stubbs et al. 2002	4	C	
32CS4487	--	Michlovic 1993; Stubbs et al. 2002	15	A	
32CS4488	--	Michlovic 1993	24	A	
32CS4489	--	Michlovic 1993; Stubbs & Ollendorf 2002	42	C	
32CS4490	--	Stubbs et al. 2002	10	C	
32CS4493	--	Michlovic 1993; Stubbs et al. 2002	23	C	
32CS4494	--	Michlovic 1993; Stubbs et al. 2002	486	C	
32CS4495	--	Michlovic 1993	6	A	
32CS4496	--	Michlovic 1993; Stubbs et al. 2002	243	C	
32CS4497	--	Stubbs et al. 2002	1	-	
32CS4498	--	Michlovic 1993; Stubbs et al. 2002	11	A	
32CS4499	--	Michlovic 1993; Stubbs et al. 2002	15	V	
32CS4500	--	Michlovic 1993; Stubbs et al. 2002	24	V	
32CS4503	--	Michlovic 1993	22	A	
32CS4899	--	Stubbs et al. 2002	473	V	
32CS4900	--	Stubbs et al. 2002	18	C	
32CS-FS	MSCCS 8	D. Sather, pers. comm. 2002	1	-	

Appendix 3. NORTH DAKOTA, Cass County

Site No.	Site Name	Reference	n=	+	Context
32CS-FS	MSCCS 14	D. Sather, pers. comm. 2002	2	-	
32CS	RE 1-	D. Sather, pers. comm. 2002	7	C	
32CS	RE 2-	D. Sather, pers. comm. 2002	9	C	

Appendix 3. NORTH DAKOTA, Dickey County

Site No.	Site Name	Reference	n=	+	Context
32DI195	Gabriel	Grohnke et al. 2008	1954	A	

Appendix 3. NORTH DAKOTA, Grand Forks County

Site No.	Site Name	Reference	n=	+	Context
32GF1	Arvilla	UM 50, UM 420	120	C	
32GF130	Omlid-1	Gregg & Picha 1989; Florin et al. 2002; Blikre & Benn 2003	629	V	
32GF	--	Bakken notes (1984)	8	A	

Appendix 3. NORTH DAKOTA, Lamoure County

Site No.	Site Name	Reference	n=	+	Context
32LM8	Kazapa	Gregg et al. 1987	13	x	Late Prehistoric
32LM8	Kazapa	Gregg et al. 1987	4	V	Plains Village
32LM8	Kazapa	Gregg et al. 1987	13	V	Plains Village?
32LM29	Walde	Gregg et al. 1987	27	C	
32LM15	Ptega	Gregg et al. 1987	74	-	Surface
32LM15	Ptega	Gregg et al. 1987	32	V	Plains Village
32LM15	Ptega	Gregg et al. 1987	10	-	Unknown
32LM22	Peterson	Gregg et al. 1987	3	V	Plains Village
32LM22	Peterson	Gregg et al. 1987	2	C	Late Plains Woodland
32LM22	Peterson	Gregg et al. 1987	17	C	Middle Plains Woodland
32LM22	Peterson	Gregg et al. 1987	1	-	Late Plains Archaic to Early Plains Woodland

Appendix 3. NORTH DAKOTA, Lamoure County

Site No.	Site Name	Reference	n=	+	Context
32LM22	Peterson	Gregg et al. 1987	72	A	Plains Archaic

Appendix 3. NORTH DAKOTA, Richland County

Site No.	Site Name	Reference	n=	+	Context
32RI775	Rustad	Michlovic & Running 2003	27	C	
32RI775	Rustad	Michlovic & Running 2003	6,985	A	
32RI775	Rustad	Michlovic & Running 2003	32	P	
32RI785	--	Dobbs 2001	317	A	Blocks 1-7
32RI785	--	Dobbs 2001	144	A	Block 10
32RI785	--	Dobbs 2001	328	A	Block 13
32RI785	--	Dobbs 2001	322	A	Block 11
32RI785	--	Dobbs 2001	1,725	A	Block 12
32RI785	--	Dobbs 2001	459	A	Block 8, Late Archaic
32RI785	--	Dobbs 2001	278	A	Block 8, Late to Middle Archaic
32RI785	--	Dobbs 2001	518	A	Block 8, Middle Archaic

Appendix 3. NORTH DAKOTA, Ransom County

Site No.	Site Name	Reference	n=	+	Context
32RM91	--	Michlovic 1993	11	A	
32RM225	Lucas	M.G. Michlovic, pers. comm. 2002	580	P	

Appendix 3. NORTH DAKOTA, Stutsman County

Site No.	Site Name	Reference	n=	+	Context
32SN57	Makacega	Gregg et al. 1987	13	x	
32SN58	Greenwood Village	Gregg et al. 1987	1	x	Protohistoric
32SN58	Greenwood Village	Gregg et al. 1987	14	x	Late Prehistoric
32SN58	Greenwood Village	Gregg et al. 1987	8	-	Unknown
32SN58	Greenwood Village	Gregg et al. 1987	8	V	Plains Village
32SN59	Olson	Gregg et al. 1987	7	C	Middle Plains Woodland
32SN59	Olson	Gregg et al. 1987	1	-	Unknown
32SN106	Larson	Gregg et al. 1987	5	P	Plains Village

Appendix 3. NORTH DAKOTA, Stutsman County

Site No.	Site Name	Reference	n=	+	Context
32SN106	Larson	Gregg et al. 1987	9	x	Late Prehistoric
32SN106	Larson	Gregg et al. 1987	6	C	Woodland
32SN106	Larson	Gregg et al. 1987	31	P	Plains Village
32SN107	Wilmart	Gregg et al. 1987	160	-	Unknown
32SN107	Wilmart	Gregg et al. 1987	10	P	Middle Plains Village
32SN120	Isan	Gregg et al. 1987	78	C	Plains Woodland
32SN120	Isan	Gregg et al. 1987	10	C	Middle Plains Woodland
32SN120	Isan	Gregg et al. 1987	669	x	Procurement and workshop
32SN121	Akata	Gregg et al. 1987	1	V	Plains Village
32SN121	Akata	Gregg et al. 1987	24	C	Early to Middle Plains Woodland
32SN121	Akata	Gregg et al. 1987	14	A	Late Plains Archaic
32SN110	Ituhu	Gregg et al. 1987	156	V	
32SN113	Tahuka	Gregg et al. 1987	137	V	
32SN246	Naze	Picha & Gregg 1987	8524	V	Component 1
32SN246	Naze	Picha & Gregg 1987	7979	C	Component 2
32SN246	Naze	Picha & Gregg 1987	1176	C	Component 3

Appendix 3. ONTARIO

Site No.	Site Name	Reference	n=	+	Context
DbJi-4	--	Hamilton 1996	24	P	
DbJi-5	--	Hamilton 1996	2	-	
DbJi-6	--	Hamilton 1996	1	-	
DbJi-7	--	Hamilton 1996	1	-	
DbJi-8	--	Hamilton 1996	2	-	
DbJi-9	--	Hamilton 1996	1	-	
DcJh-4	Simmonds	Halverson 1992	11,040	P	
DcJi-18	--	Hamilton 1996	2	-	
DcJi-19	--	Hamilton 1996	13	P	
DcJi-20	--	Hamilton 1996	139	P	
DcJi-21	--	Hamilton 1996	11	-	
DcJi-22	--	Hamilton 1996	2	-	

Appendix 3. ONTARIO					
Site No.	**Site Name**	**Reference**	**n=**	**+**	**Context**
DcJi-23	--	Hamilton 1996	18	P	
DcJi-24	--	Hamilton 1996	7	P	
DcJi-25	--	Hamilton 1996	4	P	
DcJi-26	--	Hamilton 1996	3	P	
DcJi-27	--	Hamilton 1996	2	-	
DcJi-28	--	Hamilton 1996	6	-	
DcJi-29	--	Hamilton 1996	55	P	
DcJi-30	--	Hamilton 1996	168	-	
DcJi-31	--	Hamilton 1996	6	-	
DcJi-32	--	Hamilton 1996	3	-	
DcJj-15	--	Hamilton 1996	15	-	
DcJj-16	--	Hamilton 1996	7	-	
DcJj-17	--	Hamilton 1996	3	-	
DcJj-18	--	Hamilton 1996	23	-	
DcJj-19	--	Hamilton 1996	27	-	
DcJj-20	--	Hamilton 1996	6	-	
DcJj-21	--	Hamilton 1996	8	-	
DcJj-22	--	Hamilton 1996	19	-	
DcJj-23	--	Hamilton 1996	26	P	
DcJj-24	--	Hamilton 1996	7	-	
DcJj-25	--	Hamilton 1996	6	-	
DcJj-26	--	Hamilton 1996	12	-	
DcJj-27	--	Hamilton 1996	4	-	
DdKm-1	Long Sault	Arthurs 1982, 1986	266	x	Historic
DdKm-1	Long Sault	Arthurs 1982, 1986	1,103	C	Late Woodland
DdKm-1	Long Sault	Arthurs 1982, 1986	984	C	Middle Woodland
DdKm-1	Long Sault	Arthurs 1982, 1986	808	A	Archaic
DgKl-3	Nestor Falls	Pastershank 1989	74	x	
DgKl-6	Boom-Boom	Pastershank 1989	27	-	
DgKl-7	Raft	Pastershank 1989	16	-	
DgKl-8	Narrow Bay	Pastershank 1989	18	-	
DgKl-9	Dead Tree	Pastershank 1989	5	-	
DgKl-10	Pelican	Pastershank 1989	9	C	
DgKl-11	One Scraper	Pastershank 1989	1	-	

Appendix 3. ONTARIO

Site No.	Site Name	Reference	n=	+	Context
DgKl-12	Tamarack	Pastershank 1989	6	-	
DgKl-13	Old Man Coutts	Pastershank 1989	3	-	
DgKl-14	Neebin	Pastershank 1989	92	x	
DgKl-15	Pickerel	Pastershank 1989	13	-	
DgKl-16	Saskatoon	Pastershank 1989	5	C	
DgKl-18	Two Bear	Pastershank 1989	25	-	
DgKl-21	Waiekwaminiss	Pastershank 1989	7	C	
DgKl-22	One Assawan	Pastershank 1989	2	C	
DgKl-23	Honeymoon Roost	Pastershank 1989	21	A	
DgKl-24	Gathering	Pastershank 1989	3	C	
DgKl-25	Blueberry Picking	Pastershank 1989	10	C	
DgKl-26	Pine Tree	Pastershank 1989	10	A	
DgKl-27	Gigawekamiga	Pastershank 1989	14	A	
DgKl-28	Jibatag	Pastershank 1989	5	C	
DgKl-29	Papagiwainegamig	Pastershank 1989	6	C	
DgKl-30	Site Neiash	Pastershank 1989	12	C	
DgKl-31	Nin Mawandjiton	Pastershank 1989	2	C	
DgKl-32	McCleeary	Pastershank 1989	19	-	
DgKl-33	Sandy Bar	Pastershank 1989	13	C	
DgKl-34	Mitigomij	Pastershank 1989	11	-	
DgKl-35	Clarks	Pastershank 1989	6	C	
DgKl-36	Nestor Fell	Pastershank 1989	4	C	
DgKl-37	Kramarchuk	Pastershank 1989	12	x	
DgKl-39	Neiashi	Pastershank 1989	34	C	
DgKl-40	Worholtz	Pastershank 1989	5	C	
DgKl-41	Wabanong	Pastershank 1989	1	-	
DgKl-42	Cobble Beach	Pastershank 1989	21	A	
DgKl-43	Small Beach	Pastershank 1989	6	-	
DgKl-44	Agassa	Pastershank 1989	2	-	
DgKl-45	Cyclone Point Beach	Pastershank 1989	17	A	
DgKl-46	Rusak	Pastershank 1989	1	-	
DgKl-47	Turtle Island	Pastershank 1989	17	C	
DgKl-48	Barr	Pastershank 1989	2	-	
DgKl-49	Amoo	Pastershank 1989	1	-	

Appendix 3. ONTARIO					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
DgKl-50	Wynn	Pastershank 1989	3	-	
DgKl-51	Seagull Island	Pastershank 1989	3	-	
DgKl-52	Mustayah	Pastershank 1989	1	-	
DgKl-53	Tulsi	Pastershank 1989	15	A	
DgKl-54	O'Sullivan	Pastershank 1989	13	A	
DgKl-55	Wanda Wise	Pastershank 1989	3	-	
DgKl-56	Inbetween	Pastershank 1989	3	-	
DgKl-57	Arsenault	Pastershank 1989	5	A	
DgKl-58	Trimble	Pastershank 1989	1	C	
DjKn-5	Bundoran	Speidel 1989	3,320	C	

Appendix 3. SOUTH DAKOTA					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
39BK132	--	Palmer & Justin 2006	20	A	
39BK135	--	Palmer & Justin 2006	39	A	

Appendix 3. WISCONSIN					
Site No.	**Site Name**	**Reference**	**n=**	+	**Context**
47DN234	--	Wendt 2003	228	P	
47GT25	Bass	Stoltman et al. 1984	75,324	*	
47LC34	Valley View	Withrow 1983	4,251	V	
47PI497	Bechel's Spring	Hawley & Twinde 2002	778	C	
47VE1252	Solverson	Hamilton 2002	1,053	-	